



**Ontario Geological Survey
Open File Report 6058**

**A Regional Evaluation of the
Shale Resource Potential of
the Upper Ordovician
Queenston Formation,
Southern Ontario**

2001



ONTARIO GEOLOGICAL SURVEY

Open File Report 6058

A Regional Evaluation of the Shale Resource Potential of the Upper Ordovician
Queenston Formation, Southern Ontario

by

D.K. Armstrong

2001

Parts of this publication may be quoted if credit is given. It is recommended that reference to this publication be made in the following form:

Armstrong, D.K. 2001. A regional evaluation of the shale resource potential of the Upper Ordovician Queenston Formation, southern Ontario; Ontario Geological Survey, Open File Report 6058, 148p.

© Queen's Printer for Ontario, 2001.

Open File Reports of the Ontario Geological Survey are available for viewing at the Mines Library in Sudbury, at the Mines and Minerals Information Centre in Toronto, and at the regional Mines and Minerals office whose district includes the area covered by the report (see below).

Copies can be purchased at Publication Sales and the office whose district includes the area covered by the report. Although a particular report may not be in stock at locations other than the Publication Sales office in Sudbury, they can generally be obtained within 3 working days. All telephone, fax, mail and e-mail orders should be directed to the Publication Sales office in Sudbury. Use of VISA or MasterCard ensures the fastest possible service. Cheques or money orders should be made payable to the *Minister of Finance*.

Mines and Minerals Information Centre (MMIC)
Macdonald Block, Room M2-17
900 Bay St.
Toronto, Ontario M7A 1C3

Tel: (416) 314-3800
1-800-665-4480(toll free inside Ontario)

Mines Library
933 Ramsey Lake Road, Level A3
Sudbury, Ontario P3E 6B5

Tel: (705) 670-5615

Publication Sales
933 Ramsey Lake Rd., Level A3
Sudbury, Ontario P3E 6B5

Tel: (705) 670-5691(local)
1-888-415-9845(toll-free)
Fax: (705) 670-5770
E-mail: pubsales@ndm.gov.on.ca

Regional Mines and Minerals Offices:

Kenora - Suite 104, 810 Robertson St., Kenora P9N 4J2

Kirkland Lake - 10 Government Rd. E., Kirkland Lake P2N 1A8

Red Lake - Box 324, Ontario Government Building, Red Lake P0V 2M0

Sault Ste. Marie - 70 Foster Dr., Ste. 200, Sault Ste. Marie P6A 6V8

Southern Ontario - P.O. Bag Service 43, Old Troy Rd., Tweed K0K 3J0

Sudbury - Level B3, 933 Ramsey Lake Rd., Sudbury P3E 6B5

Thunder Bay - Suite B002, 435 James St. S., Thunder Bay P7E 6S7

Timmins - Ontario Government Complex, P.O. Bag 3060, Hwy. 101 East, South Porcupine P0N 1H0

Toronto - MMIC, Macdonald Block, Room M2-17, 900 Bay St., Toronto M7A 1C3

This report has not received a technical edit. Discrepancies may occur for which the Ontario Ministry of Northern Development and Mines does not assume any liability. Source references are included in the report and users are urged to verify critical information. Recommendations and statements of opinions expressed are those of the author or authors and are not to be construed as statements of government policy.

If you wish to reproduce any of the text, tables or illustrations in this report, please write for permission to the Team Leader, Publication Services, Ministry of Northern Development and Mines, 933 Ramsey Lake Road, Level B4, Sudbury, Ontario P3E 6B5.

Cette publication est disponible en anglais seulement.

Parts of this report may be quoted if credit is given. It is recommended that reference be made in the following form:

Armstrong, D.K. 2001. A regional evaluation of the shale resource potential of the Upper Ordovician Queenston Formation, southern Ontario; Ontario Geological Survey, Open File Report 6058, 148p.

Contents

Introduction.....	1
Methodology	1
Previous Work	6
Geological Overview	7
Lithologic Components.....	9
Mineralogy	10
Internal Stratigraphy	11
Geochemical Overview.....	12
Bed Samples.....	12
Composite Samples.....	19
Geology and Geochemistry of Queenston Quarries	21
Streetsville Quarry	22
Burlington Quarry	25
Aldershot Quarry	27
Milton Quarry	29
A.C. Martin Quarry	32
Cheltenham Quarry	34
Discussion of Quarry Investigations	36
Results of the 2000 Shale Drilling Program	39
Regional Resource Evaluations	49
Niagara Peninsula	56
Regional Municipalities of Halton and Peel	57
Burlington-Oakville	57
Milton.....	58
Georgetown South	58
Brampton.....	59
Georgetown North	60
Dufferin and Simcoe Counties.....	60
Dufferin County	60
Simcoe County	61
Grey County.....	61
Conclusions and Recommendations	62
Acknowledgements.....	65
References.....	65

Appendices

Appendix 1: Mapping station information.....	71
Appendix 2: Composite sample information.....	78
Appendix 3: Bed sample information.....	97
Appendix 4: Major and minor element data for composite samples.....	111
Appendix 5: Major and minor element data for bed samples.....	119
Appendix 6: Trace element data for Milton core (OGS-83-01) samples.....	129
Appendix 7: Major and minor element data and depth intervals of samples from OGS 1989 drill holes.....	134
Appendix 8: Quarry section descriptions.....	137
Appendix 9: Locations of Ontario Geological Survey 2000 drill holes.....	144
Appendix 10: Quality control summary for Queenston Formation shale project analyses.....	146
Metric Conversion Table.....	148

FIGURES

1. Paleozoic bedrock geology map of the study area, showing locations of 2000 mapping stations, drill holes (from OGS programs in 2000, 1989 and others used in this study), thin drift areas over the Queenston Formation, municipal boundaries and urban areas, and the Niagara Escarpment Commission (NEC) Plan Area.....	back pocket
2. Location of quarries, outcrops and drill holes studied for Queenston Formation shale study.....	2
3. Location of drill holes used in Queenston Formation shale study.....	4
4. Areas of thin drift (< 8 m) over the Queenston Formation.....	5
5. Plot of CO ₂ versus CaO for all bed samples.....	13
6. Plot of CO ₂ versus LOI for all bed samples.....	15
7. Plot of K ₂ O versus Al ₂ O ₃ for all bed samples.....	16
8. Plot of SiO ₂ versus Al ₂ O ₃ for all bed samples.....	17
9. a) CO ₂ versus CaO for red and green shale samples, b) CO ₂ versus CaO for limestone and siltstone samples.....	18
10. Plot of CO ₂ versus CaO for all composite samples.....	20

11. Plot of K_2O versus Al_2O_3 for all composite samples.....	20
12. Geochemical and lithologic unit profile of Queenston Formation exposed at the Streetsville Quarry (00DKA-007).....	23
13. Geochemical and lithologic unit profile of Queenston Formation exposed at the Burlington Quarry (00DKA-002)	26
14. Geochemical and lithologic unit profile of Queenston Formation exposed at the Aldershot Quarry (00DKA-014).....	28
15. Geochemical and lithologic unit profile of Queenston Formation exposed at the Milton Quarry (00DKA-004).....	31
16. Geochemical and lithologic unit profile of Queenston Formation exposed at the A.C. Martin Quarry (00DKA-006).....	33
17. Geochemical and lithologic unit profile of Queenston Formation exposed at the Cheltenham Quarry (00DKA-003)	35
18. Histograms of CO_2 content in composite samples from Queenston Formation quarries. a) Streetsville Quarry, b) Burlington Quarry, c) Aldershot Quarry.....	37
18 cont'd. Histograms of CO_2 content in composite samples from Queenston Formation quarries. d) Milton Quarry, e) A.C. Martin Quarry, f) Cheltenham Quarry	38
19. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A1 (00DKA-045).....	40
20. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A2 (00DKA-046).....	41
21. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A4 (00DKA-047).....	42
22. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A6 (00DKA-048).....	43
23. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A8 (00DKA-049).....	44
24. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A10 (00DKA-050).....	45



25. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-B1 (00DKA-051).....	46
26. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-B4 (00DKA-052).....	47
27. Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-C2 (00DKA-054).....	48
28. Geochemical profile of Queenston Formation in Ontario Power Generation drill hole NF#33 (00DKA-043).....	50
29. Geochemical profile of Queenston Formation in drill hole OGS-83-1 (00DKA-001).....	51
30. Geochemical profile of Queenston Formation in drill hole OGS-00-C1 (00DKA-053).....	52
31. Histograms of CO ₂ content in composite samples from the 2000 OGS drill holes. a) OGS-00-A1, b) OGS-00-A2, c) OGS-00-A4	53
31 cont'd. Histograms of CO ₂ content in composite samples from the 2000 OGS drill holes. d) OGS-00-A6, e) OGS-00-A8, f) OGS-00-A10	54
31 cont'd. Histograms of CO ₂ content in composite samples from the 2000 OGS drill holes. g) OGS-00-B1, h) OGS-00-B4, i) OGS-00-C2	55

TABLES

1. Upper Ordovician and Lower Silurian stratigraphic chart for the Niagara Escarpment area.....	8
2. Summary of bed sample geochemical results.....	12
3. Summary of green shale bed sample geochemical results.....	14
4. Summary of red shale bed sample geochemical results.....	14
5. Summary of siltstone bed sample geochemical results.....	14
6. Summary of limestone bed sample geochemical results	19
7. Summary of composite sample geochemical results	19

8. Queenston Formation quarries studied	21
9. Elemental ranges and weighted averages for Streetsville Quarry and for the present working face of the quarry	24
10. Elemental ranges and weighted averages for Burlington Quarry	25
11. Elemental ranges and weighted averages for the plant section at the Aldershot Quarry.	27
12. Elemental ranges and averages for 4 outcrops (stations 00DKA-015, -016, -017, -018) on the Aldershot Quarry property	29
13. Elemental ranges and weighted averages for Milton Quarry	30
14. Elemental ranges and weighted averages for the A.C. Martin Quarry	32
15. Elemental ranges and weighted averages for Cheltenham Quarry and for the present working face of the quarry	36
16. Summary of Ontario Geological Survey 2000 drill program results	39
17. Elemental ranges and weighted averages for 9 samples from drill hole OGS-89-09	56
18. Elemental ranges and averages for 27 samples from drillhole NF#33 (00DKA-043)	57
19. Elemental ranges and weighted averages for 5 samples from drill hole OGS-89-08	58
20. Elemental ranges and weighted averages for 10 samples from drill hole OGS-89-05a	59

Introduction

The Upper Ordovician Queenston Formation shale is the primary source of raw material for the manufacturing of bricks in Ontario. This resource is extracted mainly from quarries located in the area west of Mississauga and east of the Niagara Escarpment, in the Regional Municipalities of Halton and Peel (Figures 1 (back pocket) and 2). In this area the shale resources of the Queenston Formation are located close to surface and close to market. However, access to the resource in this area is partly limited by restrictions imposed by the Niagara Escarpment Plan (NEP) and other existing land uses. Increasing urbanization threatens to limit access to the remaining potential shale resource in this area. The present state of the brick industry in Ontario was recently reviewed by Steele (2001).

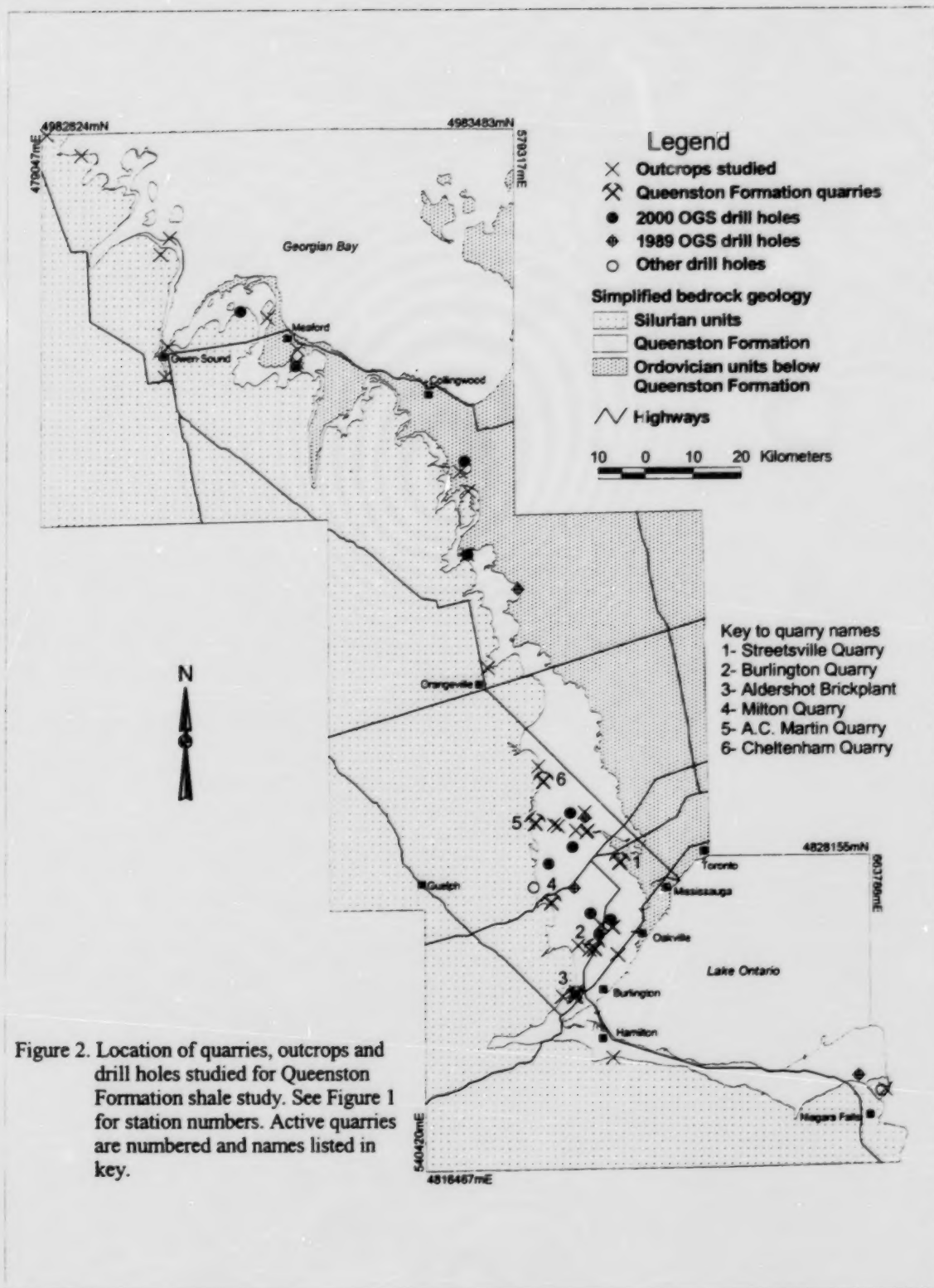
This study was initiated in 2000 by the Ontario Geological Survey (OGS) to document the geological properties of the Queenston Formation where it is presently quarried and to investigate its resource potential on a regional scale.

This study focussed on only the geological factors affecting resource potential of the Queenston Formation in its main outcrop belt, along the base of the Niagara Escarpment (Figures 1 (back pocket) and 2). These geological factors include: thickness of drift cover, general quality of the shale as indicated by its geochemistry, presence of deleterious components (e.g., gypsum), and the thickness of resource. Potential resources which fall within areas of land-use restriction (i.e., NEP areas and existing urban areas) were excluded from this study. In addition, this study did not address economic or environmental factors in evaluating potential resources. The Queenston Formation also outcrops in eastern Ontario, in the vicinity of the town of Russell, but this area was not included as part of this study.

Methodology

The overall strategy for this study involved: 1) documenting the geological characteristics of the existing resource in active quarries; 2) identifying potential resource areas based primarily on thickness of drift cover; and 3) investigating the quality of the potential resource in these thin drift areas. In addition, geological data was obtained along the length of the Queenston Formation outcrop belt in order to provide a better regional database.

Data points for this study included 6 quarries presently extracting the Queenston Formation, 36 natural or manmade outcrops, 2 previously drilled cores, and 10 new drill holes. Each of these data points was designated a mapping station and assigned a unique station number. Station numbers consist of 3 parts: the last 2 digits of the year (i.e., "00" for "2000"), the geologist's initials (i.e., "DKA"), and a 3 digit number (e.g., "001"). Stations were numbered consecutively starting at 00DKA-001. A list of the mapping



stations and information about each of them (e.g., location, type, etc.) is presented in Appendix 1. Station locations are plotted in Figure 1 (back pocket).

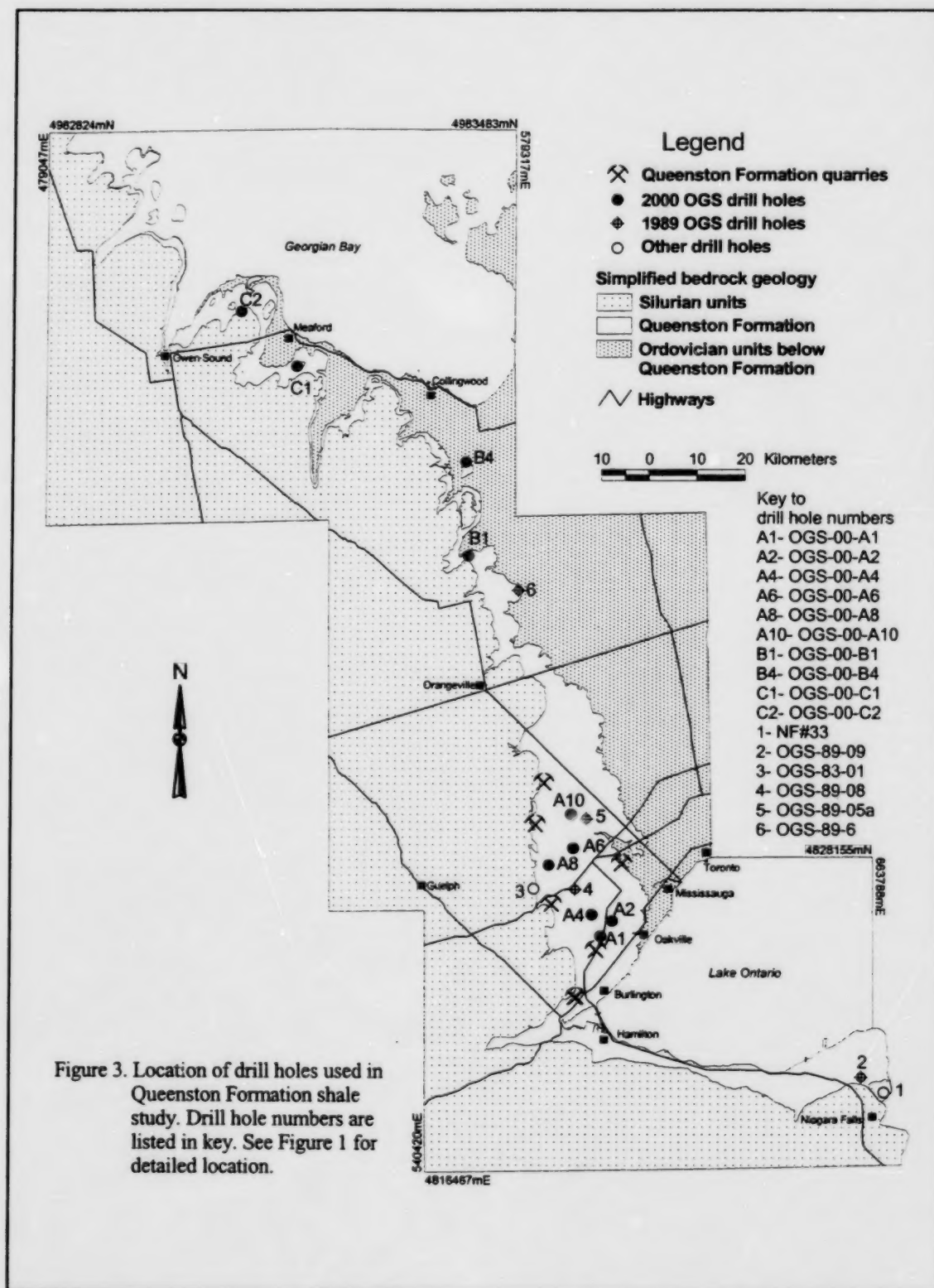
Two types of samples were taken in this study: 1) composite or continuous channel samples (taken across stratigraphy); and 2) individual bed or small interval samples. Composite samples were assigned "100" series numbers and bed samples are "000" series. Samples at a given station were assigned consecutive letters. So for example, 3 bed samples obtained at station 00DKA-002 would be numbered 00DKA002a through to 00DKA002c, and 3 composite samples at the same station would be numbered 00DKA102a to 00DKA102c. Lists of all composite and bed samples, along with location and descriptions, are presented in Appendices 2 and 3, respectively. Sample elevations listed in the tables in these appendices are measured in metres above a local datum for quarry (i.e., quarry floor) or outcrops (i.e., base of outcrop) and depth below ground surface for drill core samples. The local datum used for each station is reported in Appendix 1.

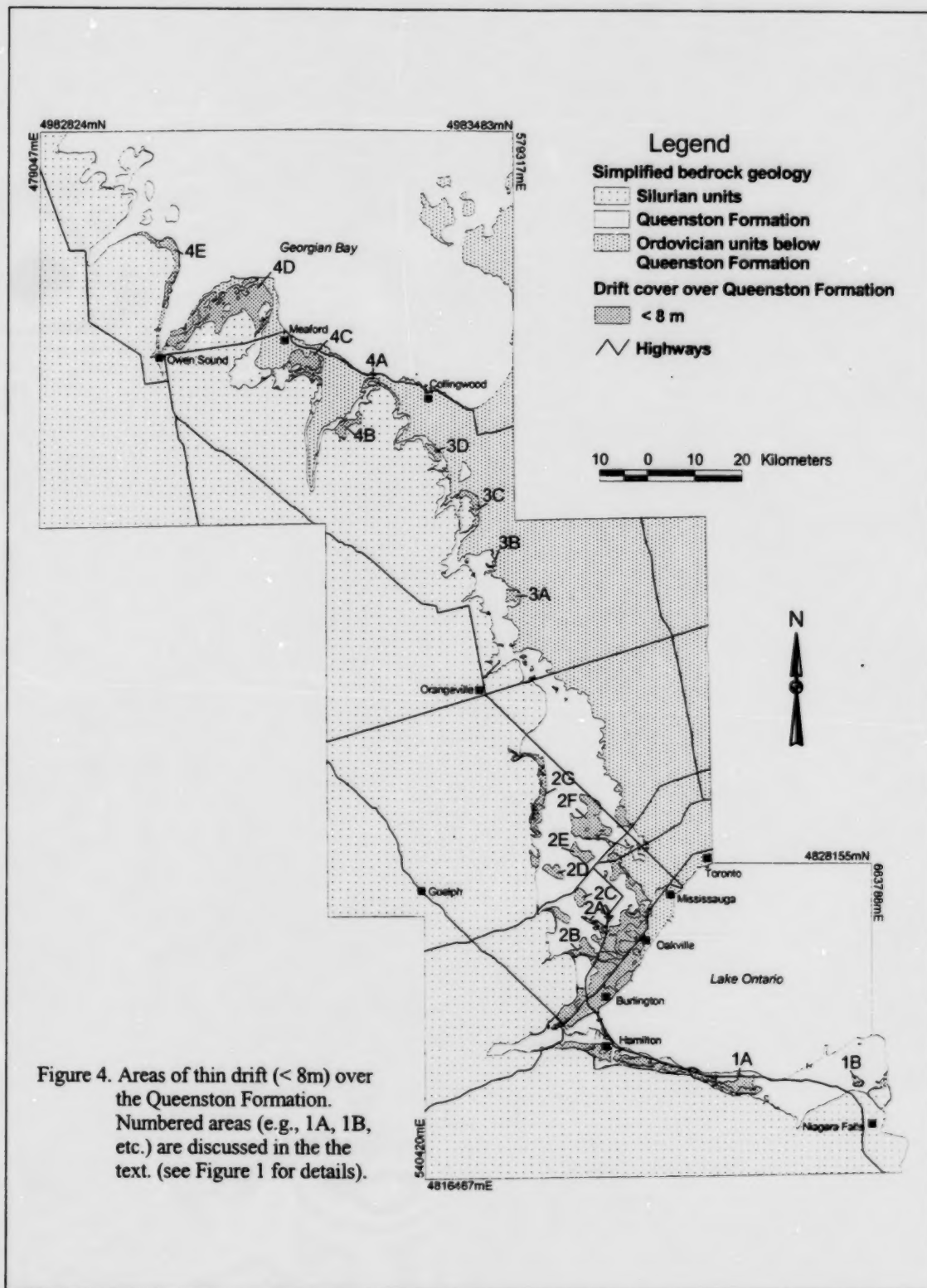
The first step in this study was to examine and describe in detail the bedrock sections exposed in each of the active Queenston shale quarries within the study area. The sections were subdivided into lithologic units which were then used as a framework for geochemical sampling. Composite samples were obtained for each accessible unit and samples of some individual beds were also obtained for petrographic and/or geochemical analysis.

Areas of thin drift over the Queenston Formation were identified mostly from published sources such as maps in Ontario Geological Survey (OGS) Aggregate Resource Inventory Papers (ARIP's; e.g., Golders Associates Ltd. and Rowell 1996a, 1996b), OGS drift thickness maps and Open File Reports (e.g., Vos 1975; Telford and Narain 1980). Published drift thickness data for the eastern Niagara Peninsula area are sparse, so thin drift data were obtained from unpublished sources (unpublished data related to Feenstra 1972). For the purpose of this study, a cut-off of 8 metres (~ 25 feet) was used to identify thin drift areas. Areas with less than 1 m (~3 feet) of drift were also compiled for this report. Thin drift areas are plotted in Figures 1 (back pocket) and 4 (labels in Figure 4 are explained in the Resource Evaluation section of this report).

The potential shale resources in the areas of thin drift were investigated using the nearest available outcrops, excavations or drill cores. Outcrop and excavation sections were described and sampled in a similar fashion to the quarry sections: they were subdivided into lithologic units which were sampled either in whole (i.e., composite samples) or in part (i.e., bed samples). In a number of cases, especially where outcrops were small, in poor condition (e.g., highly weathered or partly covered with drift), or where they consisted of lithologically homogenous strata, evenly spaced (across stratigraphy) bed samples were taken instead of composite samples.

Subsurface data required to evaluate the bedrock in specific thin drift areas was afforded by 5 cores drilled by the OGS in 1989 (Rutka and Vos 1993) and by 10 cores drilled by the OGS in 2000, as part of this study. The locations of both of these sets of drill holes





are presented in Figures 1 (back pocket) and 3, where they are identified as "1989 OGS drill holes" and "2000 OGS drill holes". The 1989 cores were not re-examined for this study, however, the geochemical data from Rutka and Vos (1993) for these holes was incorporated in the shale resource evaluation section. The 1989 data are presented in Appendix 7 of this report, along with the previously unpublished sample interval depths.

Additional potential resource targets (i.e., thin drift areas) were investigated with a drilling program conducted in the late summer and early fall of 2000 as part of this study. This program was designed to confirm thickness of drift and obtain fresh bedrock samples for analysis. Six holes were drilled in the Regional Municipalities of Halton and Peel, and 4 holes were drilled in the northern part of the study area, in the counties of Dufferin, Simcoe and Grey. The locations of these holes are plotted in Figures 1 (back pocket) and 3 and listed in Appendix 9. The 4 northern holes also provided important regional stratigraphic information.

Regional subsurface information about the Queenston Formation was also obtained by examining 2 previously drilled cores: OGS-83-1, drilled by the OGS in the Dufferin Aggregates Quarry at Milton in 1983 (Johnson 1983); and NF#33, drilled in 1991 by Ontario Hydro (now Ontario Power Generation Ltd.) near the Sir Adam Beck Generating Station at Niagara Falls. These 2 holes, assigned station numbers 00DKA-001 and 00DKA-043, respectively, were logged and systematically sampled (~ 10 cm thick samples) every 5 or 10 m through the Queenston Formation interval. The locations of these 2 holes are plotted on Figures 1 (back pocket) and 3, where they are identified as "other drill holes", and listed in Appendix 1.

All geochemical analyses were conducted by the Ontario Geoscience Laboratories. All composite samples (total of 216) and most of the bed samples (total of 273) were analyzed for major element oxides and for carbon and sulphur. Major element oxides were determined by X-ray fluorescence (XRF) and carbon (reported as CO₂) and sulphur (S) were determined by Infrared (IR) spectroscopy. Samples from drill core OGS-83-1 (station 00DKA-001) were also analyzed for a broad suite of trace and minor elements by ICP-AES and ICP-MS. The elements analyzed, and their respective analytical methods and detection limits are listed in Appendix 6.

Quality control in the laboratory analysis was evaluated using duplicate analyses and in-house standards. A quality control summary is presented in Appendix 10. For most of the elements the estimated precision is less than 2 %. Higher precision values were obtained for elemental concentrations at or near detection limits (e.g., sulphur).

Previous Work

Hamblin (1998, 1999) recently reviewed the geology of the Queenston Formation and the history of its geological investigation. The most recent academic studies of the Queenston Formation in Ontario include those by Brogly et al. (1998), Brogly (1984, 1990) and Donaldson (1989a, 1989b). Donaldson (1989a, 1989b) studied the Queenston

Formation in the subsurface of southwestern Ontario, using a single drill core and geophysical logs from a number of oil and gas exploration wells. Brogly (1984) worked primarily in the outcrop belt of the Queenston Formation, and then extended his investigations (Brogly 1990) to include 6 drill cores from the subsurface of southwestern Ontario. Earlier relevant studies include Grabau (1908), Foerste (1916, 1924), Parks (1925), Dyer (1925), Caley (1940), Sanford (1961), Liberty (1969), Liberty and Bolton (1971), and Tarrant (1977).

The industrial mineral potential of the Queenston Formation has been the subject of numerous studies spanning almost a century. Significant reports include those by Baker (1906), Keele (1924), Montgomery (1930), Brady and Dean (1966), Guillet (1964, 1967, and 1977), Vos (1975), Kwong et al. (1985), Martini and Kwong (1986), Guillet and Joyce (1987), and Rutka and Vos (1993). Guillet (1967) presented individual quarry sections with corresponding chemical and ceramic test results. Guillet (1977) and Guillet and Joyce (1987) presented a more regional perspective of the Queenston Formation (and other units) and its properties. Martini and Kwong (1986) and Kwong et al. (1985) studied the geology of clay and shale deposits in Ontario and conducted detailed ceramic tests of these units. Vos (1975) reviewed the nature of clay and shale deposits in south-central Ontario and highlighted areas of thin drift over potential shale resources in the general vicinity of the Niagara Escarpment. Telford and Narain (1980) also reviewed the industrial mineral potential of the Niagara Escarpment area. Rutka and Vos (1993) presented the results of a drilling program undertaken by the Ontario Geological Survey to test some of the areas of thin drift over the Queenston Formation.

The present study area (Figures 1 (back pocket) and 2) has been covered by a variety of federal and provincial survey Paleozoic bedrock geology maps at various scales, including: Liberty (1969), Liberty and Bolton (1971), Ontario Geological Survey (1991b), Bond and Telford (1976), Bond et al. (1976), Liberty, Bond and Telford (1976a, 1976b, 1976c), Liberty, Feenstra and Telford (1976a, 1976b), Telford (1976a, 1976b), Feenstra (in preparation), Armstrong (1993) and others. A composite of these maps has been digitally prepared for this study and forms the foundation of Figure 1 (back pocket) and other map figures in this report.

Regional subsurface information on the Queenston Formation is afforded by deep cores drilled by the Ontario Geological Survey in the early 1980's (Johnson 1983; Johnson et al. 1983, 1985).

Geological Overview

The Upper Ordovician Queenston Formation, characterized by red shales, outcrops (or subcrops beneath Quaternary drift) in a narrow belt immediately east and north of the Niagara Escarpment (Figures 1 (back pocket) and 2). From there it extends beneath younger Paleozoic bedrock units into the subsurface of southwestern Ontario (Sanford 1961). It is also found in a small outlier in a down-thrown fault-block in eastern Ontario (Williams and Telford 1986; the eastern Ontario occurrence was not studied for this

report). In the vicinity of its main outcrop belt, the formation ranges from over 300 m thick beneath the eastern end of Lake Erie to less than 50 m thick at the north end of the Bruce Peninsula (Sanford 1961). In the central part of the study area, from Hamilton to Orangeville, it thins from approximately 180 m to 120 m (Sanford 1961).

The Queenston Formation forms the uppermost part of a large clastic wedge that developed to the northeast of the Taconic Orogeny during the Late Ordovician. The formation conformably overlies grey and green marine shales and limestones of the Georgian Bay Formation and is sharply overlain by Lower Silurian units (Johnson et al. 1992), namely, sandstones of the Whirlpool Formation which give way, north of Collingwood, to limestones and dolostones of the Manitoulin Formation (Table 1). The upper contact has been called an unconformity (e.g., Johnson et al. 1992; Martini and Kwong 1986), however, there is some uncertainty – due in part to the paucity of biostratigraphically significant fossils in the upper Queenston – as to the amount of time missing at this contact, either through non-deposition or erosion (Hamblin 1999), and so the term disconformity may be more appropriate.

Table 1: Upper Ordovician and Lower Silurian stratigraphic chart for the Niagara Escarpment area (from Johnson et al. 1992).

Age	Geographic Areas		
	Niagara Peninsula area	Creemore-Collingwood area	Owen Sound area
Lower Silurian	Whirlpool Fm	Manitoulin Fm	Manitoulin Fm
		Whirlpool Fm	
Upper Ordovician	Queenston Fm	Queenston Fm	Queenston Fm
	Georgian Bay Fm	Georgian Bay Fm	Georgian Bay Fm
	Blue Mountain Fm	Blue Mountain Fm	Blue Mountain Fm

The characteristic red colour of the Queenston Formation and its general lack of marine fossils suggest that it, at least in part, was deposited in a sub-aerial to marginal marine coastal setting. Donaldson (1989b) identified a stratigraphic succession of facies in the Queenston which he interpreted as representing an upward shift from intertidal to supratidal mudflat with varying degrees of storm influence. Brogly et al. (1998) envisaged a coastal setting for the Queenston, consisting of a wide, shallow, prograding muddy shoreline displaying environments ranging from shallow marine to supratidal to coastal plain.

LITHOLOGIC COMPONENTS

The Queenston Formation consists mainly of red shale with subordinate amounts of green shale, siltstone, sandstone and limestone. The red and green shales are more accurately silty to sandy, variably calcareous mudstones, but for simplicity, and to conform with previous workers' terminology, the term "shale" will be used in this report. Siltstone, sandstone and limestone beds are more resistant to weathering and are thus commonly and collectively referred to as "hard beds". Martini and Kwong (1986) report that in the Georgetown to Hamilton area, the Queenston contains approximately 20 to 25 % siltstone interlayers (i.e., hard beds). Bioclastic limestones and grey-green shales become more predominant in the middle part of the Queenston Formation in the northern part of its outcrop belt (Brogly et al. 1998; Rudkin et al. 1998; Armstrong 1993; Armstrong and Goodman 1990; Liberty and Bolton 1971).

The main rock type constituting the Queenston Formation is massive-textured, silty to sandy shale (or mudstone) which ranges from red to red-brown to maroon in colour and from slightly to moderately calcareous. True mudstone (i.e., non-silty shale) occurs locally in the Queenston and is especially evident as thin beds and laminae in the lower parts of the formation. Green colouration of the shale occurs as small to very large mottles along vertical fractures and in laterally discontinuous beds that are commonly, although not exclusively, associated with (i.e., enveloping) thin, fine-grained sandstone or siltstone beds. Some small green mottles occur as reduction spots around small black organic "blebs" (Brogly et al. 1998). Martini and Kwong (1986) report little chemical difference between green and red shale and suggest that the colouration is due to the oxidation state of iron. The clay-sized fraction of the shales consists of the clay minerals illite (70 to 75 %) and chlorite (20 %), with minor quartz (5 to 10 %) (Martini and Kwong 1986). Minerals in the coarser grained fraction of the shales include calcite, dolomite, quartz and feldspar. Brogly et al. (1998) report a northward and westward decrease in the abundance of detrital silt and sand grains in the shales, away from the sedimentary source area (i.e., the Taconic mountains).

Light green to light red, calcareous siltstone to sandstone beds are common as thin (generally up to ~ 10 cm thick) interbeds in the Queenston Formation shale. They are generally more abundant in the middle and lower parts of the formation (Donaldson 1989b; Brogly 1990; Brogly et al. 1998; Martini and Kwong 1986). Although individual beds are commonly laterally discontinuous, they tend to occur at roughly the same stratigraphic positions, sometimes in packages, across entire outcrops or quarry exposures. These packages or coarser grained beds alternate with shale-rich intervals and may represent metre-scale shallowing-up cycles.

The silt- and sandstone beds range from dominantly siliciclastic to dominantly carbonate in composition and have varying amounts of clay minerals. They range from calcareous siltstones and sandstones to calcisiltites and calcarenites (i.e., limestones), however, for simplicity they will be referred to in this report as siltstones or sandstones. Typically, they are well-sorted and evenly textured, except for local intraclastic or bioclastic lag layers. These beds commonly contain horizontal to sub-horizontal (or low-angle)

lamination and some have ripple cross-laminated tops. More commonly, however, the tops of these beds are gradational, irregular and have a micro-cracked appearance. A.P. Hamblin (Geological Survey of Canada, personal communication, 2001) suggests that this texture may be due pedogenic processes. Larger scale, vertical desiccation cracks (i.e., mudcracks), which cut through entire beds, are common throughout the formation. Although these larger cracks rarely disturb (i.e., they remain horizontal) the host sand- and siltstone beds, tepee structures do occur in the more thinly interbedded and inter-laminated mudstones, siltstones and sandstones of the lower part of the formation.

Round and/or flat pebble conglomeratic layers and beds are commonly associated with the silt- and sandstone beds. Round pebbles are actually elliptical in shape, range up to 3 cm thick by 5 cm across, and are composed of red or green shale and small red shale intraclasts. In some cases these pebbles exhibit a roughly concentric internal banding or arrangement of detrital grains (e.g., small mud chips), suggesting that they accreted during transport. Flat pebbles or intraclasts, range up to 1.5 cm by 5 cm, and are typically laminated and composed of mudstone. Their angular nature suggests short transport after erosion (e.g., clasts ripped up by storm events) and a strong internal cohesiveness consistent with their clayey nature and possibly enhanced by algal binding (Donaldson 1989b).

Limestone interbeds in the Queenston Formation consist of fine- to coarse-grained, tabular to irregular bedded calcisiltites and calcarenites (as described above), as well as fossiliferous, locally argillaceous and bioturbated, medium- to coarse-grained, bioclastic limestones. The latter limestones are restricted mostly to the northern part of the outcrop belt where they occur in the middle of the Queenston Formation in association with grey to green shale (Broglie et al. 1998; Armstrong 1993; Liberty and Bolton 1971). Common fossils in these limestone beds include brachiopods, bryozoans, ostracods, bivalves, nautiloids (Rudkin et al. 1998).

MINERALOGY

Guillet and Joyce (1987), based on data compiled from previous reports, reported an average mineral composition (based on samples from 9 quarries) for the Queenston Formation of 60 % clay minerals (illite abundant and chlorite common), 26 % quartz, 11 % calcite, < 2 % dolomite and < 2 % feldspars. Martini and Kwong (1986) conducted more detailed mineralogical analysis on composite channel sample from 2 quarries (at Georgetown and Grimsby), and determined the main mineralogical components of the Queenston to be 43 to 45 % illite, 8 to 12 % chlorite, 25 to 33 % calcite, up to 8 % dolomite, and 2 to 4 % feldspars.

Gypsum is a significant accessory mineral in the Queenston Formation. It is especially significant as a deleterious component in brick manufacturing, staining bricks and, in extreme cases, causing corrosion of brick kilns. Gypsum occurs in the shales and siltstone beds of the Queenston as nodules of various size and colour, and as thin (up to 2 cm thick) white fibrous fracture-filling seams or veins. The nodules vary from less than 1

cm diameter red nodules that locally appear to have been reworked, to large (approximately 10 cm across) single or composite, white to orange nodules that are commonly associated with gypsum seams. Nodules tend to occur in broad strata-bound horizons and are most common in the middle of the formation. Gypsum seams are horizontal to sub-horizontal and occur in the middle through lower parts of the formation. Un-mineralized vugs occurring locally in the upper parts of drill cores, may be dissolved gypsum nodules.

INTERNAL STRATIGRAPHY

No formal subdivision of the Queenston Formation has been defined, however, some previous workers have proposed informal subdivisions or facies, based mainly on the relative abundance of lithologic constituents. Brogly (1984) proposed an informal three-fold subdivision of the Queenston Formation in the Hamilton-Brampton area: a lower unit consisting of interbedded red mudstone and limestone; a middle unit consisting of red mudstone and abundant siltstone; and an upper unit consisting mainly of red mudstone. In a drill core at Chatham, Donaldson (1989b) identified 4 stratigraphic facies, from bottom to top: 1) interlaminated mudstone and calcarenite; 2) thinly bedded calcarenite and mudstone with anhydrite nodules; 3) calcarenites with abundant intraclasts; and 4) graded calcarenites and mudstones. Brogly et al. (1998) identified 14 facies comprising the Queenston Formation, which were combined into 3 facies associations. They correlated these facies associations among 6 drill holes across southwestern Ontario.

In general, the Queenston Formation can be subdivided into 3 parts: an upper part consisting mainly of massive red shale; a middle part consisting of varying proportions of red and green shale, light green and light red siltstone, sandstone and limestone, and intraclastic conglomerate; and a lower part consisting of the same components as the middle unit, but tending to be thinner bedded and locally interlaminated. Contacts between these 3 parts are gradational and they are rarely exposed in a single outcrop. In the Bruce Peninsula area, the middle part of the Queenston Formation contains a distinctive unit, consisting of grey-green shale and grey bioclastic limestones (Armstrong 1993; Johnson et al. 1985). This three-fold subdivision appears to be widespread and likely represents fluctuations in relative sea level (Brogly et al. 1998).

For this study, individual outcrop or quarry sections and drill cores were subdivided into metre-scale units of local significance. Two main lithologic criteria were used to define units: 1) abundance of coarser (than shale) grained beds (i.e., siltstone, sandstone, intraclastic conglomerate, and limestone); and 2) presence of gypsum nodules or seams. It was easier to include green silty shale beds with the coarser grained beds, and so a percentage of the total coarse/green beds (i.e., non-red shale components) within a unit is commonly presented in drill core logs and section descriptions.

Although no detailed correlations were attempted among mapped sections or logged cores, general stratigraphic position could be inferred from geographic location in the outcrop belt and by comparison with deep drill holes.

Geochemical Overview

Major and minor element geochemistry is useful to help in identifying lithologic characteristics and potential deleterious components and as a first screen to evaluate resource quality. Follow-up work involving ceramic testing is required for definitive shale resource evaluation.

BED SAMPLES

Bed or spot samples were analyzed in order to characterize individual lithologic constituents. A total of 273 bed samples were analyzed for major element oxides, CO₂, and S. The bed sample set consists of 129 red shale samples, 37 green shale samples, 37 consisting of both red and green shale, 34 siltstone samples, 23 limestone samples, and 13 samples with significant gypsum content. Bed sample locations and descriptions are presented in Appendix 3 and their analytical results are presented in Appendix 5. A summary of the range average median and standard deviation for this data set is presented in Table 2.

analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
maximum	63.30	18.02	0.29	9.89	48.05	1.37	5.47	0.24	0.96	8.17	40.46	101.19	39.80	4.65
minimum	5.32	1.70	0.05	1.48	0.44	0.02	0.47	0.04	0.05	0.68	5.74	88.07	0.21	n.d.
average	48.26	12.70	0.11	3.46	11.02	0.43	3.74	0.14	0.65	5.16	13.94	99.62	9.78	0.11
median	49.85	13.38	0.10	3.20	9.37	0.27	3.88	0.14	0.68	5.44	13.01	99.82	8.72	0.02
standard deviation	8.53	2.90	0.03	1.17	7.07	0.35	0.92	0.02	0.14	1.65	5.40	1.20	6.03	0.46

Cross-plots of element contents are useful in determining the dominant element-mineral relationships. The strong correlation between CO₂ versus CaO (Figure 5) illustrates that calcite is the main carbonate mineral in the Queenston Formation. Samples plotting above the "calcite line" (calculated from the stoichiometric proportions of CaO and CO₂ in calcite) in Figure 5, that is, with excess CO₂, indicate the presence of other carbonate minerals such as dolomite. Excess CaO (i.e., plotting below the calcite line) indicates the presence of other minerals containing calcium, such as gypsum. Most of the samples plotting below the calcite line contain gypsum. Thus CO₂ is a relatively good proxy for carbonate content. Calcite (CaCO₃) content can be approximated by multiplying the CO₂ content by the ratio of the atomic weights of CaCO₃ and CO₂ (i.e., a multiplication factor of 2.27 times CO₂ content).

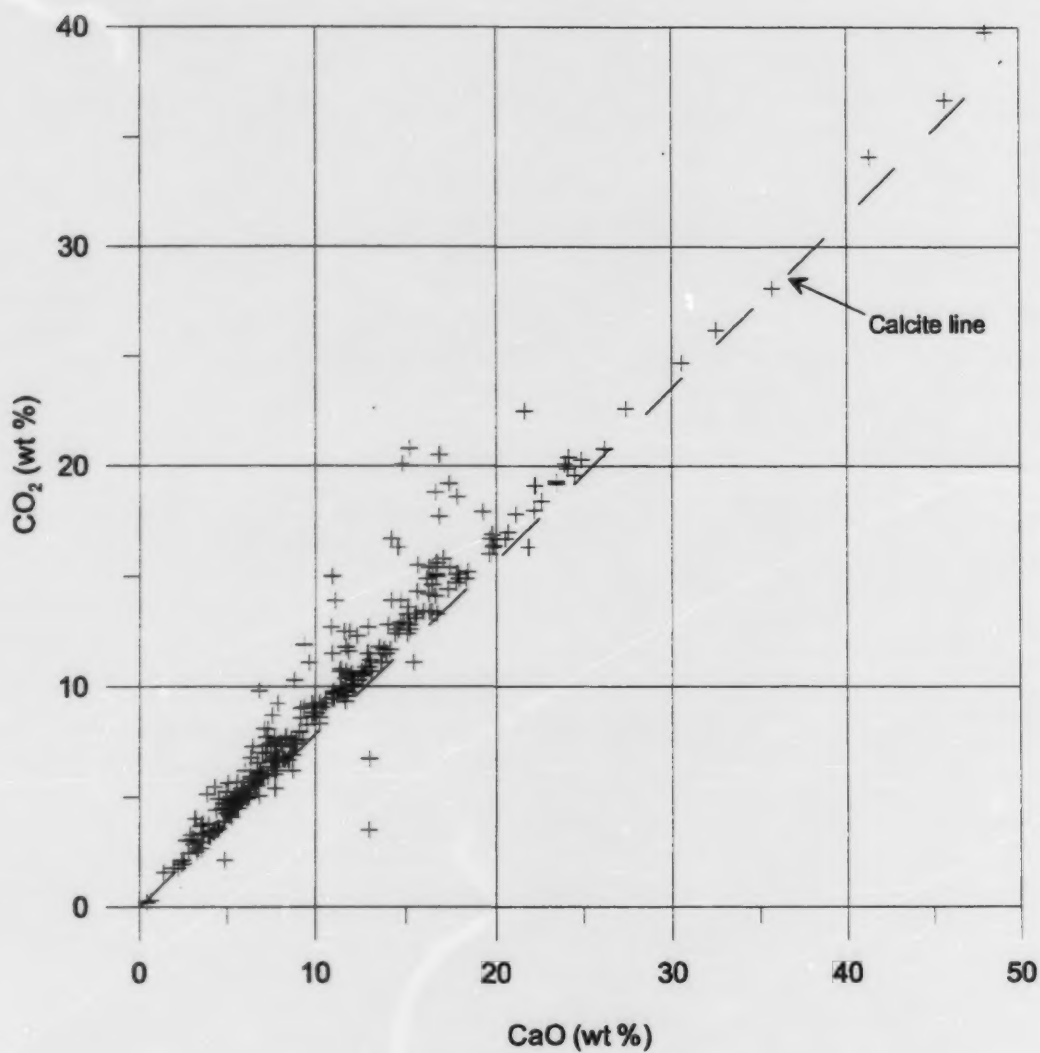


Figure 5: Plot of CO₂ versus CaO for all bed samples (n = 273).
Calcite line calculated stoichiometrically.

The strong correlation between CO₂ and loss on ignition (LOI) (Figure 6) indicates LOI is mainly due to carbonate content. The positive x-axis intercept indicates that some of the LOI content (approximately 5 % at low CO₂ content) is from other sources, such as from water bound in clay minerals.

A positive relationship between K₂O and Al₂O₃ (Figure 7) is consistent with illite being the main mineralogical component of the Queenston Formation (see Mineralogy section).

A weak positive correlation between SiO₂ and Al₂O₃ for all bed samples except limestones (Figure 8) indicates that there are a number of minerals containing these elements and that quartz is likely the principle component responsible for SiO₂ content.

As noted previously (Martini and Kwong 1986), there is little chemical difference between green and red shales. Significant overlap in carbonate content between these 2 populations can be seen in a plot of CO₂ versus CaO (Figure 9a) and in the overlap of their ranges in Tables 3 and 4. Similarly, there is significant overlap in CO₂ content for samples identified as limestone and siltstone (Figure 9b; Tables 5 and 6).

Table 3 – Summary of green shale bed sample geochemical results (n=37). From data set in Appendix 5.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
maximum	61.90	18.02	0.18	7.56	22.21	1.35	5.38	0.21	0.91	6.10	24.99	100.68	22.5	1.35
minimum	30.37	7.58	0.05	1.94	0.65	0.02	2.03	0.12	0.37	2.15	5.74	98.31	0.31	0.01
average	48.08	12.67	0.11	4.02	11.41	0.31	3.86	0.15	0.65	4.00	14.42	99.68	10.74	0.10
median	48.83	12.54	0.10	3.78	10.94	0.25	3.86	0.15	0.68	3.85	13.43	99.77	9.82	0.02
standard deviation	8.23	2.60	0.03	1.37	6.43	0.27	0.84	0.02	0.14	1.02	5.18	0.53	5.65	0.24

Table 4 – Summary of red shale bed sample geochemical results (n=129). From data set in Appendix 5.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
maximum	58.79	17.18	0.16	6.30	19.81	1.29	5.25	0.17	0.85	8.17	24.31	100.75	17.7	0.06
minimum	34.42	9.07	0.06	2.10	1.39	0.10	2.45	0.11	0.45	3.90	6.58	99.01	1.57	0.01
average	49.22	14.16	0.09	3.45	8.66	0.34	4.18	0.14	0.69	6.33	12.54	99.79	7.77	0.02
median	51.11	14.44	0.09	3.28	7.68	0.19	4.22	0.14	0.72	6.43	11.51	99.83	6.99	0.02
standard deviation	6.33	1.53	0.02	0.72	4.28	0.29	0.56	0.01	0.10	0.87	3.91	0.37	3.89	0.01

Table 5 – Summary of siltstone bed sample geochemical results (n=34). From data set in Appendix 5.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
maximum	63.30	14.31	0.23	9.89	24.86	1.37	4.12	0.24	0.84	6.08	22.99	101.19	20.80	0.27
minimum	36.20	5.22	0.08	1.57	3.90	0.09	1.84	0.12	0.36	2.00	7.74	99.09	3.42	0.01
average	50.93	10.17	0.14	3.24	12.96	0.81	2.82	0.16	0.62	3.43	14.56	99.83	11.74	0.04
median	51.35	10.23	0.14	2.61	12.91	0.86	2.72	0.15	0.62	3.24	14.11	99.81	11.45	0.02
standard deviation	8.13	2.40	0.04	1.94	5.90	0.38	0.68	0.02	0.13	0.87	4.98	0.47	5.51	0.06

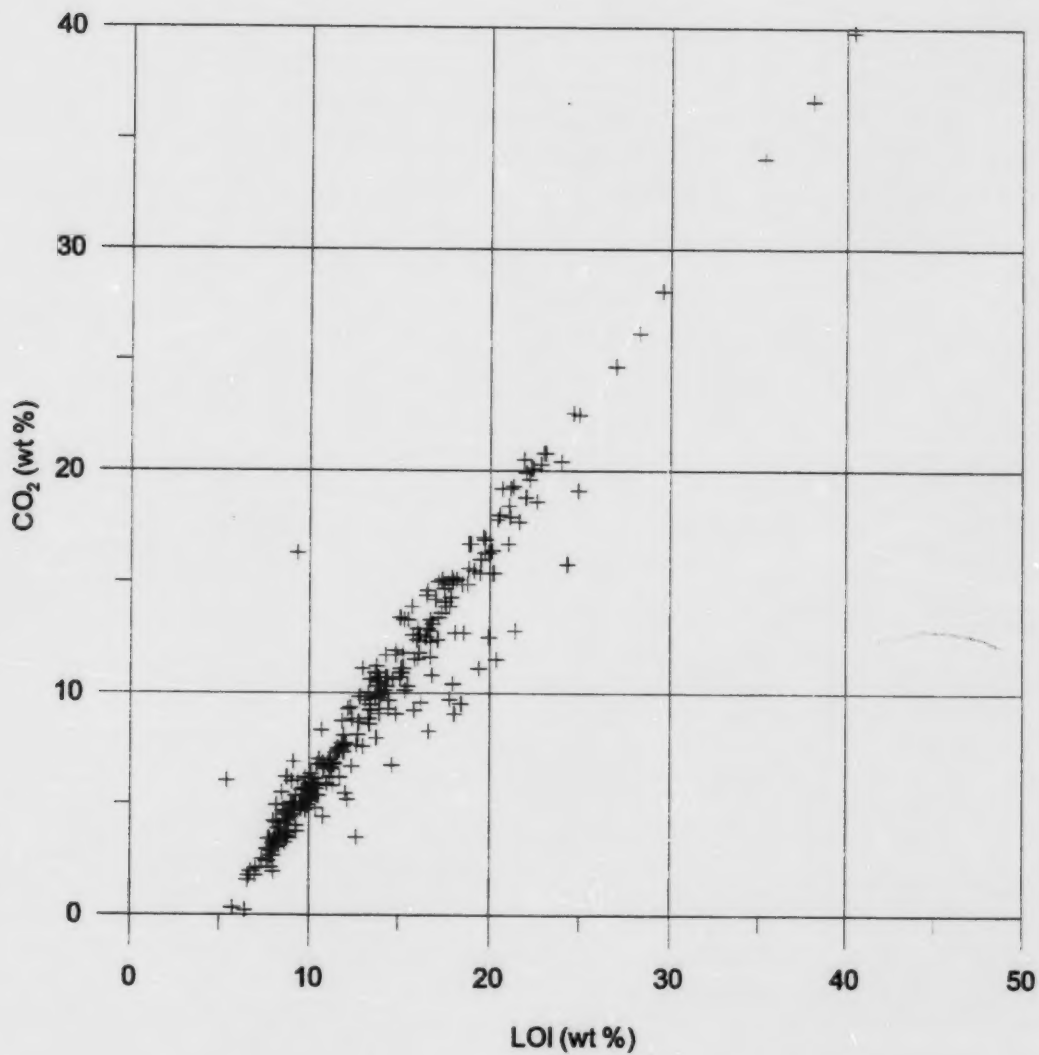


Figure 6: Plot of CO₂ versus LOI for all bed samples (n = 273).

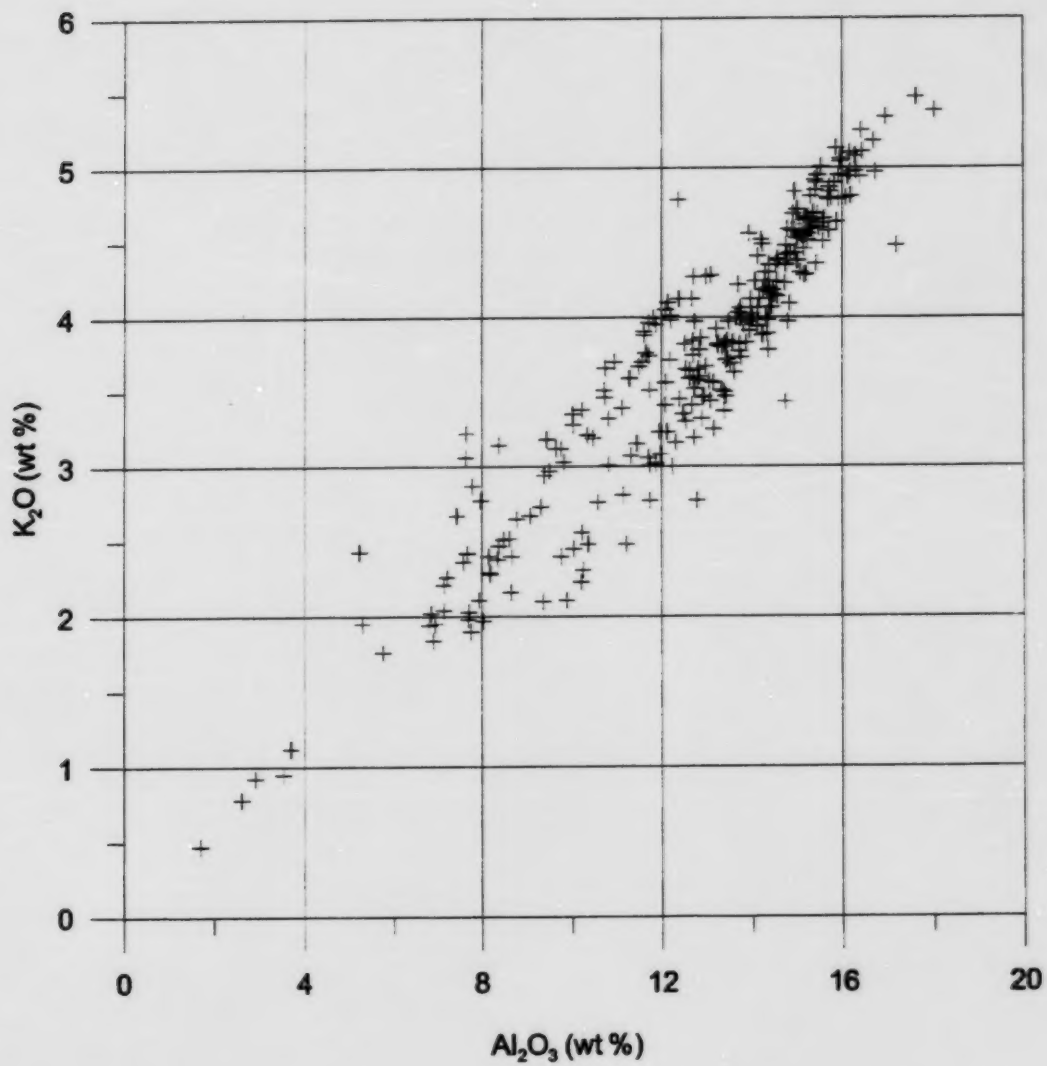


Figure 7: Plot of K_2O versus Al_2O_3 for all bed samples ($n = 273$).

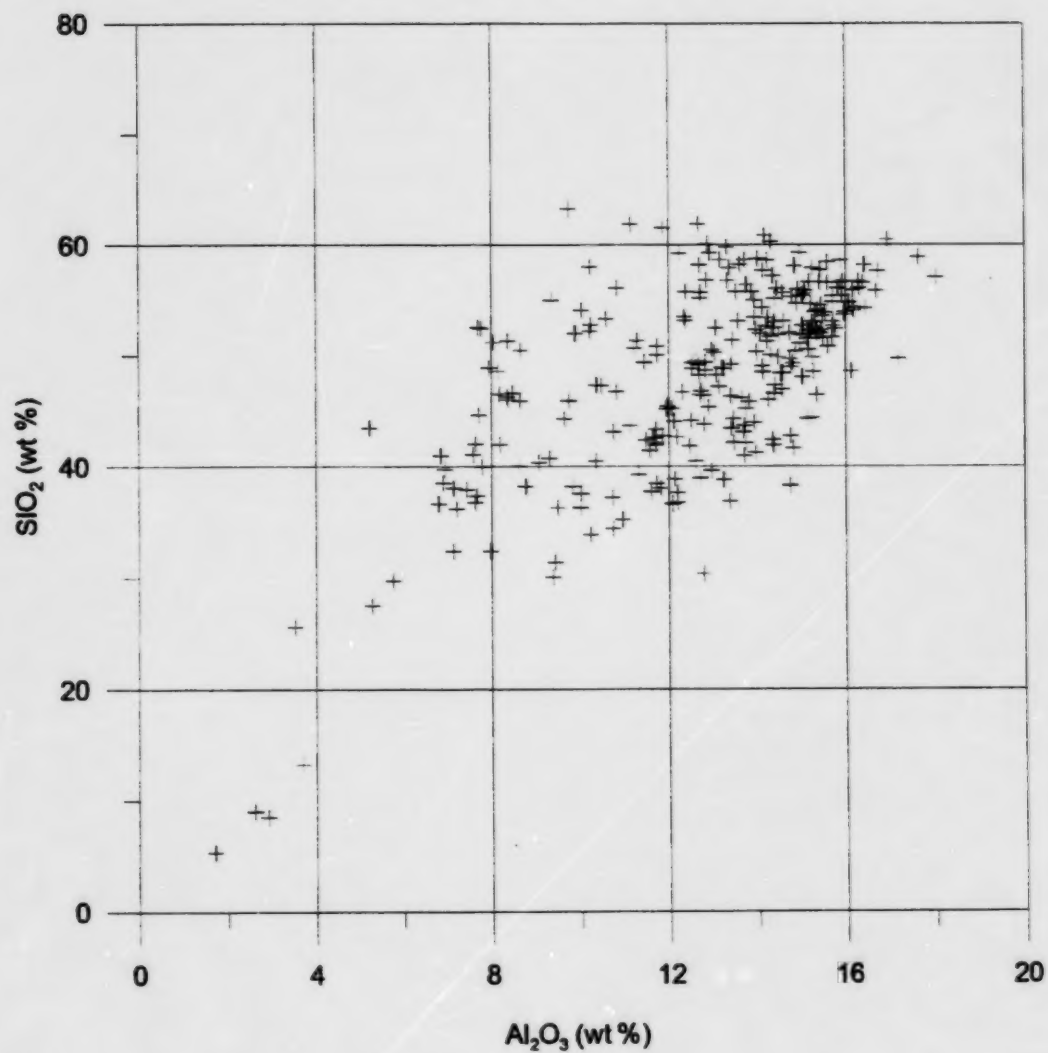


Figure 8: Plot of SiO_2 versus Al_2O_3 for all bed samples ($n = 273$).

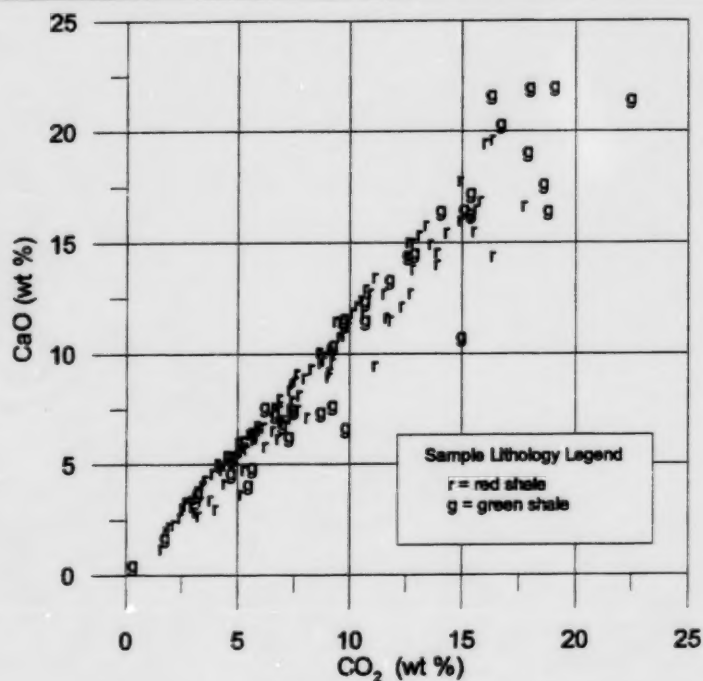


Figure 9a: CO₂ versus CaO for red and green shale samples.

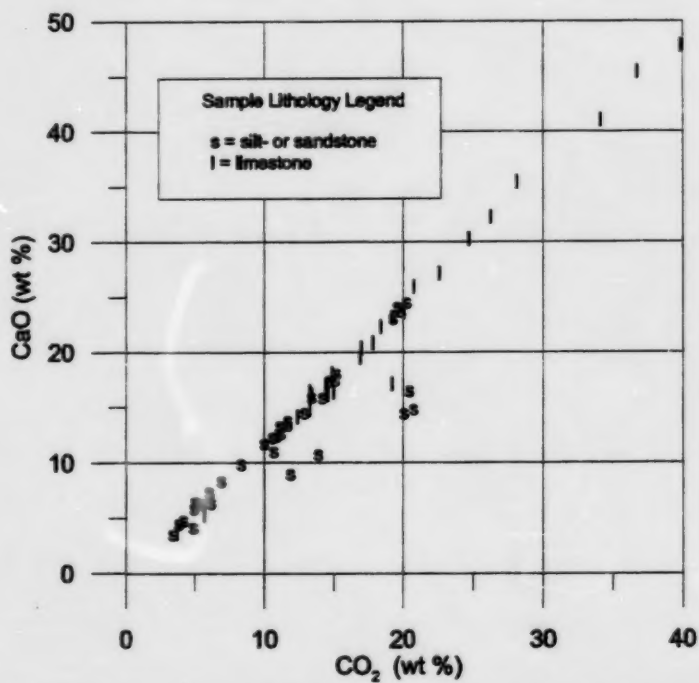


Figure 9b: CO₂ versus CaO for limestone and siltstone samples.

Table 6 – Summary of limestone bed sample geochemical results (n=23). From data set in Appendix 5.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
maximum	52.55	11.95	0.29	6.16	48.05	1.24	3.23	0.18	0.67	3.54	40.46	100.58	39.8	0.27
minimum	5.32	1.7	0.08	1.48	14.42	0.08	0.47	0.04	0.05	0.68	15.1	98.66	12.4	0.01
average	36.96	7.07	0.16	2.67	24.69	0.64	2.06	0.14	0.42	2.41	22.67	99.89	20.56	0.05
median	40.09	7.76	0.16	2.49	21.13	0.6	2.21	0.15	0.46	2.39	20.67	99.92	18.4	0.03
standard deviation	13.33	2.36	0.04	0.91	9.91	0.36	0.68	0.04	0.16	0.69	7.33	0.39	7.76	0.07

The bed sample data set includes 27 samples obtained from drill core OGS-83-1 (station 00-DKA-001). These were also analyzed for 51 trace and minor elements and the results are presented in Appendix 6 along with basic statistics (i.e., range, average, median and standard deviation) for each element. These trace and minor element data have not been analyzed in detail for this study.

COMPOSITE SAMPLES

Composite or continuous channel samples were analyzed in order to characterize lithologic units and whole sections. Where composite sample data were averaged to characterize a whole section, element contents were weighted according to sample interval. Composite sample data give a more accurate picture of the bulk chemistry of the formation. A total of 216 composite samples were analyzed for major element oxides, CO₂, and S. These samples were obtained from 6 quarries, 10 outcrops and 9 drill holes. Composite sample locations and descriptions are presented in Appendix 2 and their analytical results are presented in Appendix 4. A summary of the range average median and standard deviation for this data set is presented in Table 7.

Table 7: Summary of composite sample geochemical results (n=216). Full data set presented in Appendix 4.														
analyte	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
maximum	58.97	16.84	0.20	7.90	38.64	1.15	5.27	0.18	0.83	7.66	33.61	100.02	32.40	1.00
minimum	16.10	4.29	0.06	1.64	2.82	0.09	1.51	0.07	0.18	1.75	6.31	95.37	2.04	n.d.
average	45.79	12.07	0.11	3.33	12.99	0.51	3.52	0.14	0.61	5.03	15.06	99.16	11.33	0.07
median	46.23	12.23	0.11	2.95	12.33	0.49	3.52	0.14	0.63	5.06	14.80	99.24	11.15	0.03
standard deviation	7.29	1.91	0.02	1.05	5.43	0.30	0.58	0.01	0.11	0.98	4.34	0.53	4.88	0.14

The homogenous nature of composite samples, as compared with bed samples, generally results in narrower elemental ranges (cf. Tables 2 and 7). Inter-element relationships, however, are similar for composite samples as for bed samples (cf. Figures 5 and 7, with Figures 10 and 11).

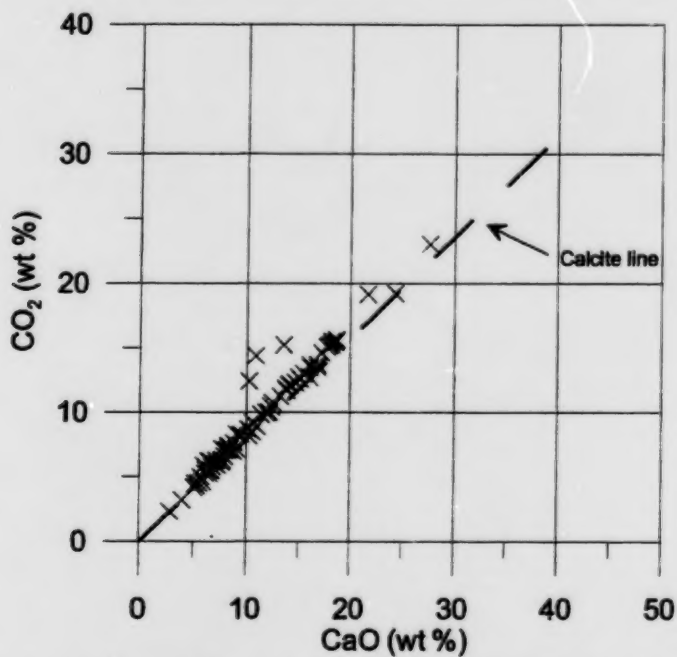


Figure 10: Plot of CO₂ versus CaO for all composite samples ($n = 216$). Calcite line calculated stoichiometrically. Compare with Figure 5.

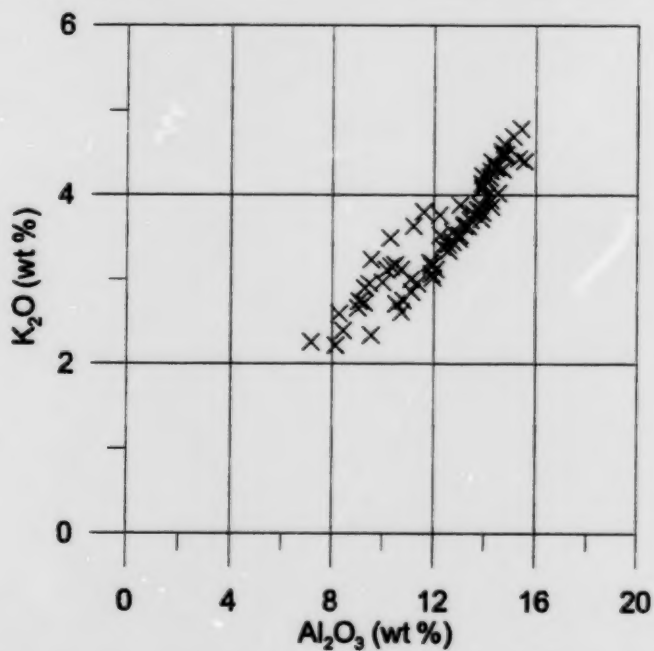


Figure 11: Plot of K₂O vs Al₂O₃ for all composite samples ($n = 216$). Compare with Figure 7.

Composite data, plotted versus height (for quarries or outcrops) and depth (for drill core) along with other lithologic parameters, are presented in figures in the following sections. Regional geochemical trends are also discussed in a later section.

Geology and Geochemistry of Queenston Quarries

During the summer of 2000, 3 companies, Canada Brick Ltd., Brampton Brick, and Century Brick were quarrying the Queenston Formation at 6 locations in the area between Cheltenham, Burlington and Mississauga (Table 8; Figure 1 (back pocket); Steele 2001). These quarries supplied raw material for 4 brick plants operating at Streetsville (Canada Brick), Burlington (Canada Brick), Brampton (Brampton Brick) and Hamilton (Century Brick). Canada Brick was also building a plant adjacent to its new quarry site at Aldershot, west of Burlington.

Table 8: Queenston Formation quarries studied (see Appendix 1 for details; locations plotted on Figure 1 (back pocket)).

Quarry Name (alternate)	OGS Station #	Quarry Operator	Location
Burlington (Tansley, Diamond Clay)	00DKA- 002	Canada Brick	north side of Highway 5 (Dundas Street) between Appleby Line and Bronte Creek – part lots 2, 3 and 4, concession 1 N.D.S., former Nelson Township, City of Burlington, Regional Municipality of Halton.
Cheltenham	00DKA- 003	Brampton Brick	southwest of the Village of Cheltenham, on the west side of Peel Road 1, north of Peel Road 9 – lots 29 and 30, concession 5, former Chinguacousy Township, Town of Caledon, Regional Municipality of Peel.
Milton (Milton Heights)	00DKA- 004	Canada Brick	west of Milton, on the west side of Regional Road 22, north of Steeles Avenue – part lots 1 and 2, concession 7, former Nassagaweya Township, Town of Milton, Regional Municipality of Halton.
A.C. Martin (Georgetown)	00DKA- 006	Century Brick	west of Georgetown, on the north side of the 22nd Sideroad, between Highway 7 and the 8th Line – lot 23, concession 8, former Esquesing Township, Town of Halton Hills (Georgetown), Regional Municipality of Halton.
Streetsville (Canada Brick)	00DKA- 007	Canada Brick	in Mississauga (Streetsville), on the north side of Britannia Road, east of Erin Mills Parkway – part lots 6 and 7, concession 5 WHS, former Toronto Township, City of Mississauga, Regional Municipality of Peel.
Aldershot	00DKA- 014	Canada Brick	behind new brick plant on north side of North Service Road, north of Highway 403, and west of King Road – part lot 3, concession 1, lots 1, 2 and 3, concession 2, former East Flamborough Township, City of Burlington, Regional Municipality of Halton.

These 6 quarries afford relatively fresh exposures of the Queenston Formation at different stratigraphic levels and geographic locations. The base of the formation is exposed in the sump of the Streetsville Quarry at Mississauga (see also Rutka and Vos 1993). The middle of the formation is exposed in the Burlington Quarry. The Aldershot Quarry property, consisting of mapping stations 00DKA-014 to -018, exposes the middle to upper portions of the Queenston. The upper part of the formation is exposed in the Cheltenham, Milton and A.C. Martin quarries.

The bedrock exposed in each of the 6 quarries was studied in detail, with sections measured and subdivided into local units based on common lithologic characteristics. A local datum, typically the quarry floor, was selected at each quarry (local data are listed in Appendix 1). Lithologic descriptions and geochemical results for each of the quarry sections are presented in the following sections.

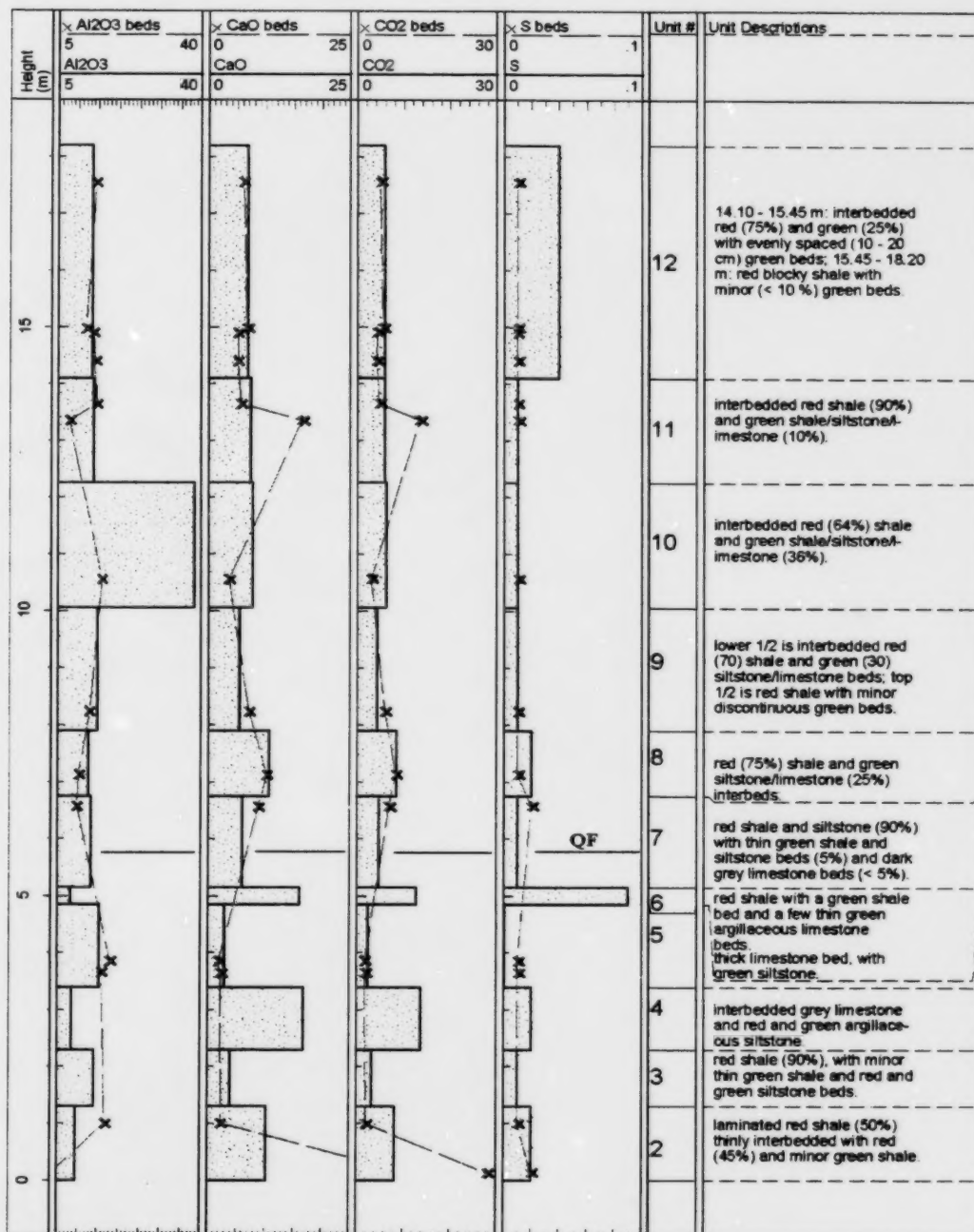
STREETSVILLE QUARRY

The Streetsville Quarry (OGS station 00DKA-007) is operated by Canada Brick Ltd. and is located in Mississauga on the north side of Britannia Road, east of Erin Mills Parkway (Table 8, Figures 1 (back pocket) and 2). This quarry and the associated brick plant have been in operation since 1956 (Guillet 1967). The shale resources are nearly depleted and the plant and quarry are slated for closure in the near future (R. Martin, Canada Brick, personal communication, 2000). It is approximately 20 m deep and exposes approximately 18.20 m of Queenston Formation overlying an unknown thickness of Georgian Bay Formation in the water-filled sump. In June 2000 the southern quarry face in the southwest corner of the quarry exposed approximately 12.45 m of the Queenston Formation.

In 1989, the Ontario Geological Survey drilled a borehole, numbered OGS-89-10, in this quarry, intersecting 6.7 m of overburden, 9.7 m of Queenston Formation and 13.2 m of Georgian Bay Formation (Rutka and Vos 1993). It is uncertain exactly where in the quarry this hole was drilled and the relative elevation of its collar to the currently exposed strata.

The section measured in June 2000 consisted of a composite of 3 intervals: the east side of the sump, immediately north of the pumphouse; the drainage ditch leading to the sump from the southwest corner of the quarry; and the southern wall near the southwest corner. The water level in the sump was selected as datum for the measured section. The main quarry floor in the southwest corner of the quarry was approximately 5.75 m above the water level.

The exposed Queenston Formation strata was subdivided into 11 units based on lithologic characteristics. An additional unit comprises material found in spoil piles immediately adjacent to the sump pond. This material was derived from below water level in the sump and contained material lithologically consistent with the Georgian Bay Formation. This spoil pile material was assigned unit number 1. Units 2 through 7 were exposed in



and adjacent to the drainage ditch. The upper 90 cm of unit 7 was also exposed in the base of the southern wall, as were all of units 8 through 12. Descriptions of these units are presented in Table 1 of Appendix 8. Brief descriptions of the units are also presented in Figure 12, along with corresponding vertical plots of selected major and minor element contents.

Unit 1 consists of the Georgian Bay Formation that is likely exposed beneath the water level in the sump, as indicated in material found in spoil piles immediately adjacent to the sump pond. The spoil piles consist mainly of 2 types of limestone slabs: grey (brown weathering), tabular bedded, horizontally to sub-horizontal laminated, fine- to medium-grained limestone, occasionally with a shelly fossil lag and rippled top; and grey (brown weathering), fossiliferous, slightly irregularly bedded, bioclastic limestone, with abundant brachiopods and bryozoans. Characteristic grey and green shale interbeds of this formation were likely weathered and washed away from the slabs in these spoil piles.

Units 2 through 7 are exposed in the walls of the sump and in a drainage ditch which leads to the southwest corner of the quarry. In general, these units consist of interbedded red and green shales, fine-grained silt- and sandstones, and grey limestones. Unit 4 contains limestone beds which range from tabular and laminated to rippled to irregular, bioturbated and bioclastic. Red and green shale dominated intervals range up to 1.50 m thick.

Units 7 through 12 are exposed in the southern wall of the quarry. These units essentially consist of intervals of mainly red shale interbedded with intervals of interbedded red and green shale and light green fine-grained sandstone. No gypsum was observed in the Streetsville section. A low angle reverse fault was observed in the wall of the southwest corner of the quarry. The fault has an apparent orientation of 50°/28°SE and an apparent offset of 60 cm.

The elemental ranges, weighted averages for the Streetsville Quarry and those for the working face of the quarry are presented in Table 9. Note that the working face has a generally lower CO₂ content than the underlying units (Figure 12 and Table 9).

Table 9: Elemental ranges and weighted averages (from 11 composite samples) for Streetsville Quarry and for the present working face (w.f.) of the quarry (n=6). See Appendix 4 for the complete data set.

analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
weighted average	55.48	16.82	0.11	2.57	7.67	0.76	3.62	0.14	0.71	5.85	9.65	99.48	6.16	0.01
minimum	48.13	8.14	0.06	1.64	2.82	0.57	2.22	0.13	0.46	2.87	6.31	99.16	2.33	n.d.
maximum	58.97	38.30	0.20	2.99	16.79	1.15	4.43	0.15	0.82	7.66	16.05	99.88	13.70	0.09
w.f. weighted average	55.14	17.98	0.11	2.65	7.06	0.71	3.80	0.14	0.73	6.01	9.47	99.40	5.76	0.02
w.f. min.	51.90	12.57	0.09	2.44	5.33	0.57	3.34	0.14	0.65	5.08	8.03	99.16	4.28	0.01
w.f. max.	58.90	38.30	0.17	2.91	10.58	0.85	4.30	0.15	0.76	6.53	11.74	99.79	8.46	0.04

Guillet (1967) reported an average CO₂ content of 4.79 % for the working face, which at that time was 7.77 m high. He also reported that test briquettes made from this shale burned from salmon red to brown-red colour. The average CO₂ of the present working face is similar (cf. 5.76%, Table 9) and the present through-body brick colour is red (R. Martin, Canada Brick, personal communication, 2000).

BURLINGTON QUARRY

The Burlington Quarry (OGS station 00DKA-002) and brick plant are located near the former village of Tansley, north of Burlington, on the north side of Highway 5 (Dundas Street), between Appleby Line and Bronte Creek (Table 8, Figures 1 (back pocket) and 2). Diamond Clay Products Ltd. began this operation in 1959 (Guillet 1967) and it is now owned and operated by Canada Brick Ltd. In June 2000, this plant was producing bricks made from shale extracted from the Burlington, Milton and Aldershot quarries (R. Martin, Canada Brick, personal communication, 2000).

The section measured in June 2000 is located in the northeast corner of the quarry, adjacent to the settling ponds. The datum used was a thick green bed located approximately 1 m above the water level in the settling pond and at a level approximately equivalent to the quarry floor in the southern part of the quarry. The measured section included 18.20 m of Queenston Formation overlain by up to 5 m of Quaternary overburden. The southwestern face of the quarry may expose an additional few metres of the Queenston Formation at the top of the section, but it was not accessible for detailed examination or sampling.

The Queenston Formation section at the Burlington Quarry was subdivided into 8 units (Figure 13). The topmost unit was not accessible for sampling. The unit descriptions are presented in Table 2 of Appendix 8 and brief unit descriptions are also presented in Figure 13, along with corresponding plots of selected major and minor element contents. Elemental ranges and weighted averages for the Burlington Quarry section are presented in Table 10.

Table 10: Elemental ranges and weighted averages (from 11 composite samples) for Burlington Quarry. See Appendix 4 for the complete data set.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
weighted average	44.15	9.79	0.14	2.75	16.92	0.77	2.77	0.16	0.57	4.00	17.38	99.41	14.20	0.03
minimum	42.43	9.02	0.13	2.61	11.88	0.72	2.66	0.15	0.54	3.73	13.41	98.96	9.98	0.02
maximum	50.82	11.33	0.15	2.94	18.63	0.95	3.12	0.16	0.67	4.43	18.51	99.73	15.60	0.06

In this quarry the Queenston Formation consists of interbedded red shale, green shale, light red and light green siltstone to fine-grained sandstone and some limestone beds. These tend to be arranged in intervals with dominantly red shale and those containing significant green or red silt- or sandstone beds. The siltstone and sandstone beds are

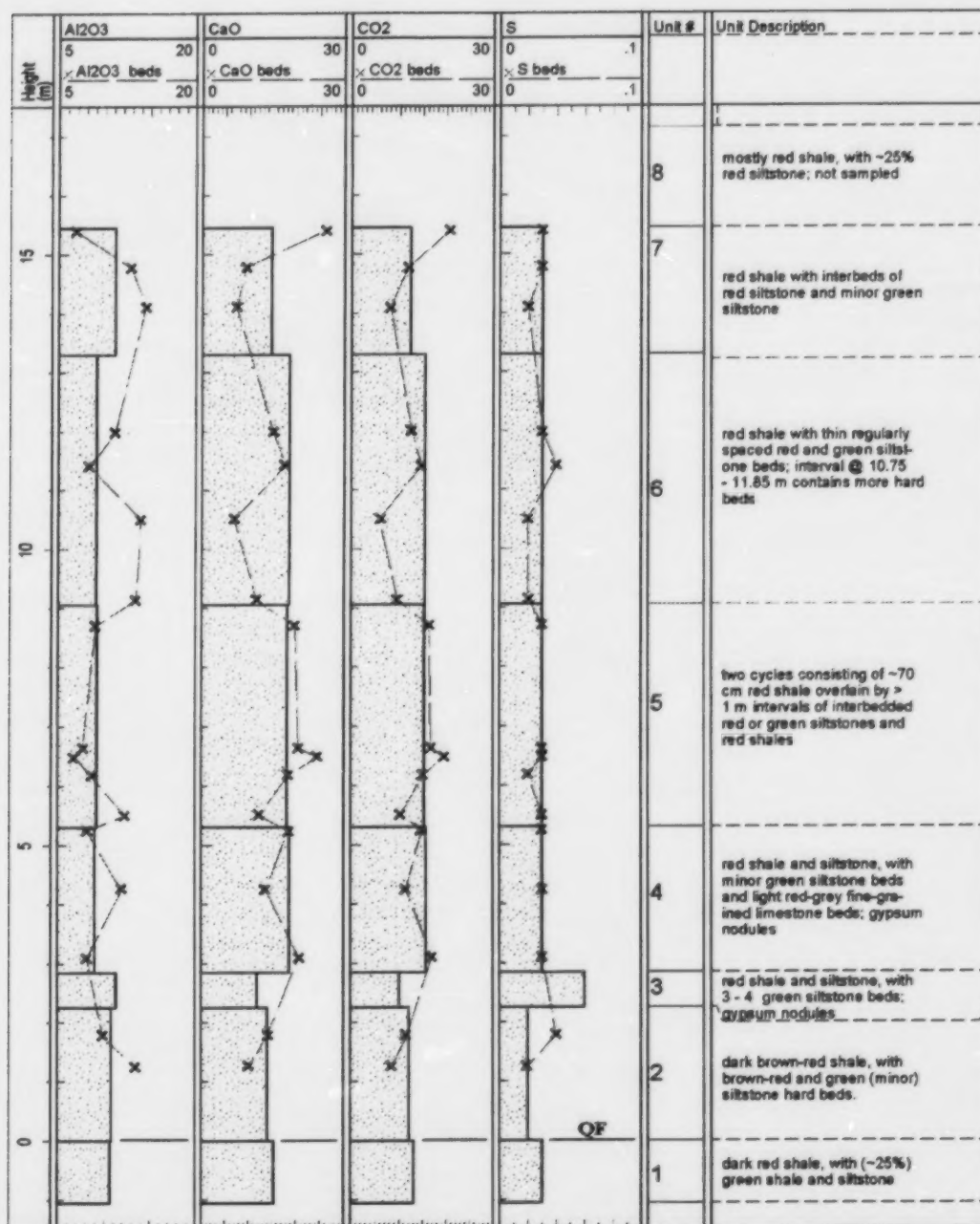


Figure 13: Geochemical and lithologic unit profile of Queenston Formation exposed at the Burlington Quarry (00DKA-002). Only profiles of selected elements are presented here; the complete geochemical data sets are presented in Appendices 4 and 5. Lithologic units are more thoroughly described in Table 2 of Appendix 8. Bars represent composite values and X's connected with dashed lines represent bed sample values. All elemental concentrations are in weight percent (wt%). QF = quarry floor.

commonly planar to ripple laminated, and locally have rippled tops. Ripple crest orientations include 73° at 0.25 m, 165° at 3.3 m, and 168° at 9.05 m. Large white gypsum nodules occur in unit 3 and up to the 3.7 m level in unit 4. Thin, sub-horizontal gypsum seams occur near the top of unit 3.

Guillet (1967) reported an average CO₂ content of 12.47 % for a 14.33 m interval of drill core obtained at the site of this quarry by the operator at that time. He also reported that test briquettes made from this shale burned from a yellow to buff colour, which agrees with the through-body colour of brick that is currently being produced (R. Martin, Canada Brick, personal communication, 2000).

ALDERSHOT QUARRY

Canada Brick Ltd. is presently building a brick plant and developing a quarry north of Aldershot on the west side of Burlington (Table 8, Figures 1 (back pocket) and 2). The property consists of 3 parcels of land which straddle King Road, on the north side of North Service Road, north of Highway 403. Part of the eastern parcel is the site of a quarry previously operated by National Sewer Pipe Ltd. (Guillet 1967). Part of the western parcel was previously quarried by Halton Ceramics Ltd. (Golders Associates Limited and Rowell, 1996a). The new brick plant is being built in the westernmost parcel and the main section measured for this study, station 00DKA-014, is located immediately behind the plant. Other outcrops on the property were examined and sampled for this study; these include stations 00DKA-015, -016, -017 and -018 (see Appendix 1 for detailed location information).

The measured section, exposing a total of 23.45 m of the Queenston Formation, was subdivided into 8 units (Figure 14). The topmost unit was not fully accessible for a composite sample, however, 2 bed samples were obtained. Unit descriptions are presented in Table 3 of Appendix 8 and brief unit descriptions are presented in Figure 14, along with corresponding plots of selected major and minor element contents. Elemental ranges and weighted averages for the Aldershot Quarry section are presented in Table 11.

Table 11: Elemental ranges and weighted averages (from 7 composite samples) for the plant section (station 00DKA-014) at the Aldershot Quarry. See Appendix 4 for the complete data set.

analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
weighted average	51.33	14.34	0.11	3.24	8.03	0.27	4.25	0.14	0.73	5.80	11.09	99.31	6.79	0.06
minimum	46.78	13.01	0.09	3.06	5.25	0.21	3.63	0.14	0.65	4.74	9.12	98.90	4.52	0.02
maximum	53.81	15.53	0.13	3.39	12.43	0.35	4.71	0.16	0.78	6.72	14.34	99.75	10.40	0.18

In this section the Queenston Formation consists mainly of red shale with subordinate thin interbeds of light green siltstone and fine-grained sandstone and associated green shale. Small gypsum nodules and thin sub-horizontal gypsum seams are common in units

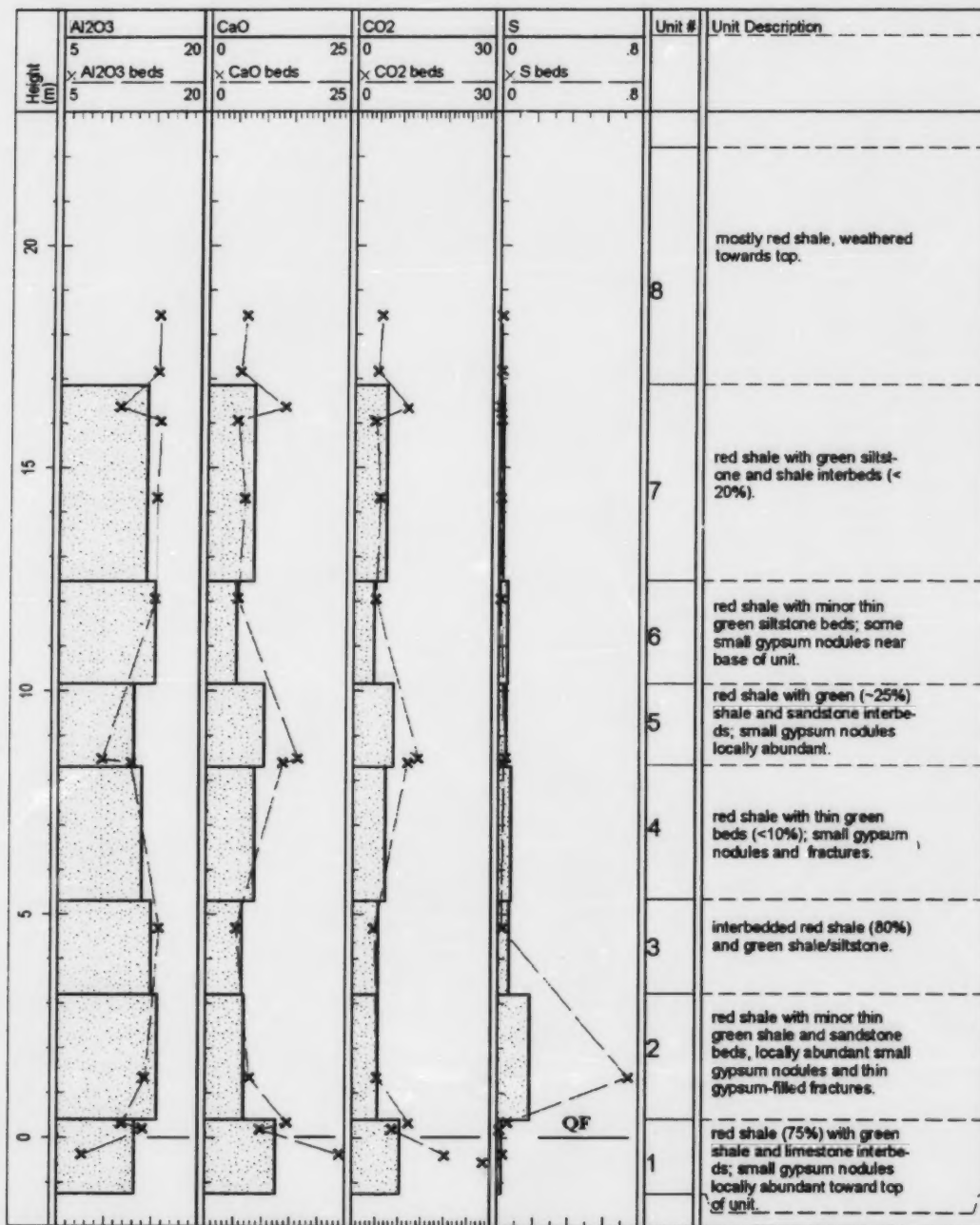


Figure 14: Geochemical and lithologic unit profile of Queenston Formation exposed at the Aldershot Quarry (00DKA-014). Only profiles of selected elements are presented here; the complete geochemical data sets are presented in Appendices 4 and 5. Lithologic units are more thoroughly described in Table 3 of Appendix 8. Bars represent composite values and X's connected with dashed lines represent bed sample values. All elemental concentrations are in weight percent (wt%). QF = quarry floor.

1 and 2 and occur locally in units 4, 5 and 6 (see Appendix 2 for details). Siltstone and fine-grained sandstone beds are commonly horizontally laminated and locally, ripple cross-laminated. These coarser grained beds are typically less than 10 cm thick and most are laterally discontinuous. The topmost unit, unit 8, consists mainly of weathered red shale.

As mentioned above, 4 natural outcrop sections, located in ravines on the Aldershot property above station 00DKA-014, were also examined and sampled (bed samples only; see Appendix 3 for sample descriptions). Two of these stations, 00DKA-017 and 00DKA-018, consist of relatively thick sections of red shale, with minor green shale beds and mottles, and very minor light green siltstone. Station 00DKA-017 is located in the western parcel of the quarry property, and exposes approximately 17.50 m (partly covered) of mostly red shale. Station 00DKA-018 is located in a ravine at the north end of the eastern parcel and exposes approximately 12.50 m of mainly red shale. In these 2 thick sections, bed samples were systematically obtained every 1.5 m or 3.0 m. The average and range of elemental contents of all 4 sections in the upper Aldershot Quarry property are presented in Table 12. The strata exposed in these outcrops and possibly in unit 8 of station 00-DKA-014, can be assigned to the upper part of the Queenston Formation.

Table 12: Elemental ranges and averages (from 18 bed samples) for 4 outcrops (stations 00DKA-015, -016, -017, -018) on the Aldershot Quarry property. See Appendix 5 for the complete data set.

analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
average	52.41	14.61	0.10	3.06	7.29	0.16	4.41	0.14	0.74	6.00	10.99	99.91	6.51	0.01
minimum	45.21	10.83	0.08	2.46	2.81	0.10	3.32	0.14	0.60	3.00	7.68	99.34	2.43	n.d.
maximum	56.14	16.68	0.15	3.41	14.72	0.42	5.18	0.15	0.82	7.74	16.58	100.48	12.90	0.02

Guillet (1967) reported that the National Sewer Pipe Ltd. property consisted of 2 quarry sections, south and north, which were 10.21 m and 9.45 m high respectively, and separated by approximately 9.14 m of covered interval. Lithologically these generally compare favourably with station 00DKA-014 and the upper 2 stations, 00DKA-017 and 00DKA-018, respectively. Guillet (1967) reported a composite average CO₂ content for both sections of 5.88 % and that test briquettes made from this shale burned a brown to dark brown colour.

MILTON QUARRY

The Milton Quarry (OGS station 00DKA-004) is located west of Milton, on the west side of Regional Road 22, north of Steeles Avenue (Table 8, Figures 1 (back pocket) and 2). There has been a long history of shale excavation by the brick industry at this and adjacent properties (e.g., Baker 1906; Guillet 1967). In June 2000, this quarry was being operated by Canada Brick and supplied raw material to their Burlington brick plant.

The main face of the quarry is oriented approximately northwest-southeast, with the highest part being the northwest corner. The face is approximately 600 m long and up to 28 m high. The section measured in June 2000 was a composite of the west and north faces in the northwest corner of the quarry. An additional, approximately 2 m of section is exposed in a drainage ditch and sump, but this was not examined.

The Queenston Formation in the Milton Quarry was subdivided into 10 units, which are described in Table 4 of Appendix 8. Brief unit descriptions are also presented, along with corresponding plots of selected major and minor element contents, in Figure 15. Composite samples were taken of all units, except for the thin basal unit 1 and the top 2.50 m of unit 10, which was inaccessible. The elemental ranges, weighted averages for composite samples from the Milton Quarry section are presented in Table 13.

Table 13: Elemental ranges and weighted averages (from 9 composite samples) for Milton Quarry. See Appendix 4 for complete data set.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
weighted average	50.99	14.38	0.10	3.55	7.48	0.23	4.35	0.14	0.73	6.02	11.39	99.35	6.67	0.01
minimum	49.52	12.24	0.09	3.08	5.73	0.12	3.52	0.14	0.65	3.85	10.62	98.90	4.99	n.d.
maximum	53.15	15.41	0.11	4.16	11.39	0.42	4.78	0.15	0.76	6.84	13.65	99.71	9.82	0.02

In this quarry the Queenston Formation consists mainly of red shale with subordinate thin interbeds of green shale and associated thinner beds of light green siltstone to fine-grained sandstone. Green beds tend to occur in groups or packages, commonly doublets or triplets, in which individual beds are laterally discontinuous, but the package is traceable for a greater distance along the quarry face. These green bed packages were commonly used to define unit contacts or in some cases were defined as units themselves. Medium to large green shale mottles occur locally in the section. Green beds tend to decrease in abundance towards the top of the section. Small (2 to 3 cm diameter) calcite-lined vugs were observed in unit 8 at 17.25 to 17.35 m. These vugs occur at approximately the same level as "calcite geodes" reported by Guillet (1967) and are likely the same thing.

A low angle reverse fault was noted in the eastern face of the quarry. The fault has an apparent orientation of 210°/14°W and apparent offset of 25 cm.

Guillet (1967) reported an average CO₂ content of 6.67 % for a composite section (including sump) approximately 36.7 m high at the Milton Brick Co. Quarry. This value is identical to the weighted average CO₂ content determined in this study (see Table 13). He also reported that test briquettes from this quarry generally burned to a brown colour. R. Martin (Canada Brick, personal communication, 2000) reported that material from this quarry produces a dark red brick.

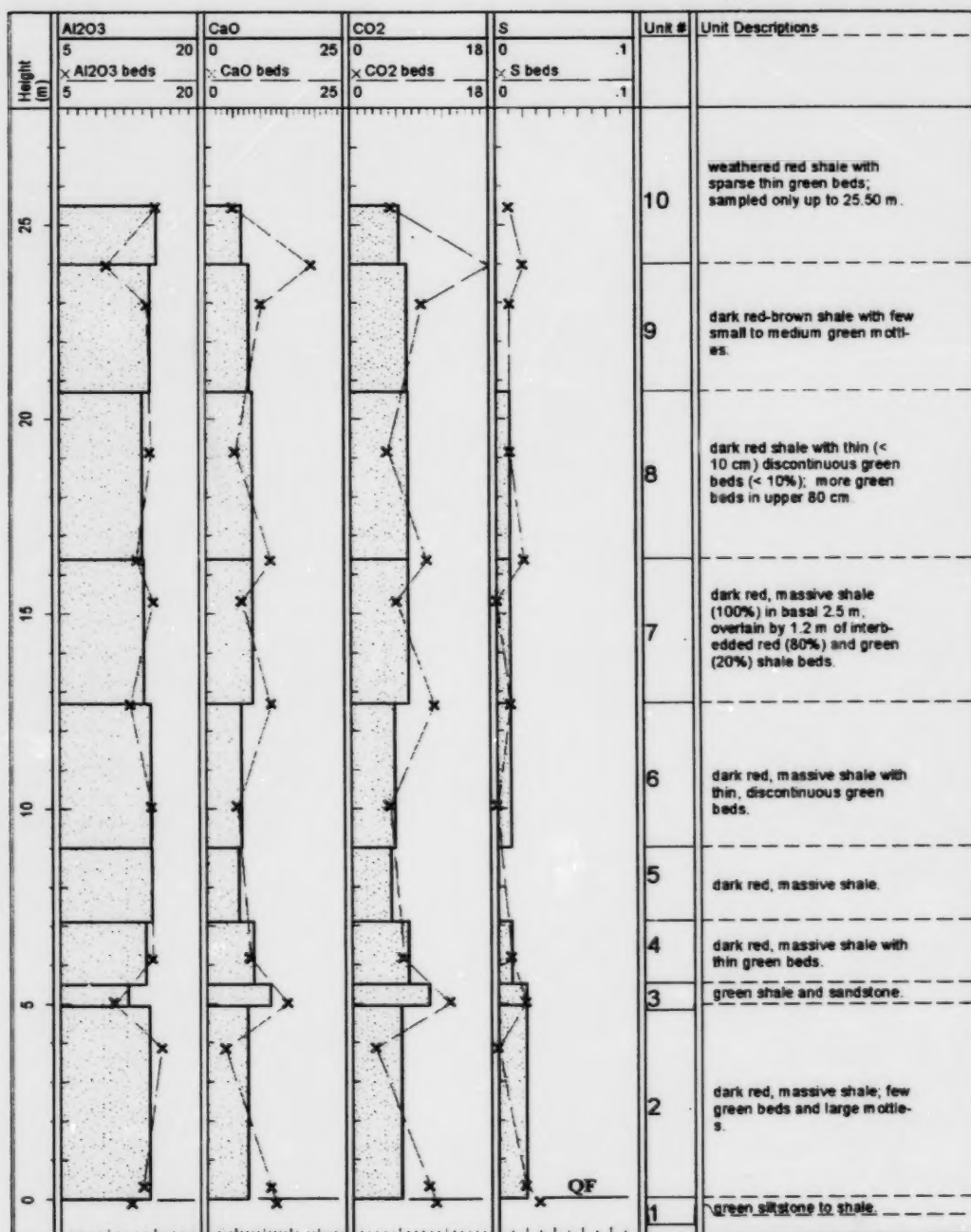


Figure 15: Geochemical and lithologic unit profile of Queenston Formation exposed at the Milton Quarry (00DKA-004). Only profiles of selected elements are presented here; the complete geochemical data sets are presented in Appendices 4 and 5. Lithologic units are more thoroughly described in Table 4 of Appendix 8. Bars represent composite values and X's connected with dashed lines represent bed sample values. All elemental concentrations are in weight percent (wt%). QF = quarry floor.

A.C. MARTIN QUARRY

The A.C. Martin Quarry (OGS station 00DKA-006) is located west of Georgetown (now called the Town of Halton Hills), on the north side of the 22nd Sideroad, between Highway 7 and the 8th Line (Table 8). A.C. Martin Ltd. opened this quarry in the early 1980's (Guillet 1983). It is presently operated by Century Brick, who use material from this quarry in their plant in Hamilton (J. Alfano, Century Brick, personal communication, 2000).

The main face of the A.C. Martin Quarry, oriented roughly northwest, is approximately 100 m long and up to 11 m high. The section measured in June 2000 was a composite of the southeast face (partial bench) and the southwest face. The surface of the southwest face was weathered and slumped, so detailed examination and sampling was restricted to one of the numerous natural drainage ditches which cut through the weathered shale.

The Queenston Formation in the A.C. Martin Quarry was subdivided into 3 units, which are described in Table 5 of Appendix 8. Brief unit descriptions are also presented, along with corresponding plots of selected major and minor element contents, in Figure 16. Composite samples were taken of all units and these data are presented in Appendix 4 and summarized in Table 14.

Table 14: Elemental ranges and weighted averages (from 3 composite samples) for the A.C. Martin Quarry. See Appendix 4 for complete data set.														
analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
weighted average	49.64	14.49	0.10	3.82	8.15	0.13	4.42	0.14	0.71	6.25	11.76	99.61	7.48	n.d.
minimum	47.71	14.26	0.10	3.66	6.66	0.13	4.32	0.14	0.68	5.92	10.37	99.54	6.18	n.d.
maximum	52.05	14.75	0.10	3.87	9.08	0.14	4.60	0.14	0.75	6.36	12.79	99.73	8.35	0.01

In this quarry the Queenston Formation consists of mainly red shale with subordinate thin, laterally discontinuous, light green siltstone to fine-grained sandstone beds and associated green shale. Green shale occurs as thin beds and as envelopes around siltstone beds. Locally in unit 1, the green shale envelope expands into large lobate mottles which appear to be centered on cross-cutting sub-vertical fractures with an apparent strike of 130°.

The weighted average CO₂ content for this quarry is 7.48 % and bricks made with this material are red-orange in colour (M. Rixner, Century Brick, personal communication, 2001). Guillet (1983) presented some geochemical data from this quarry which at that time exposed approximately 4.3 m of the Queenston Formation. Guillet's data did not include values for CO₂, however, CaO content ranged from 7.85 % in the lower 2 m to 4.36 % in the upper 2.3 m. These correspond to calculated (assuming most of the CaO and CO₂ are in calcite) CO₂ contents of 6.16 % and 3.42 %, respectively.

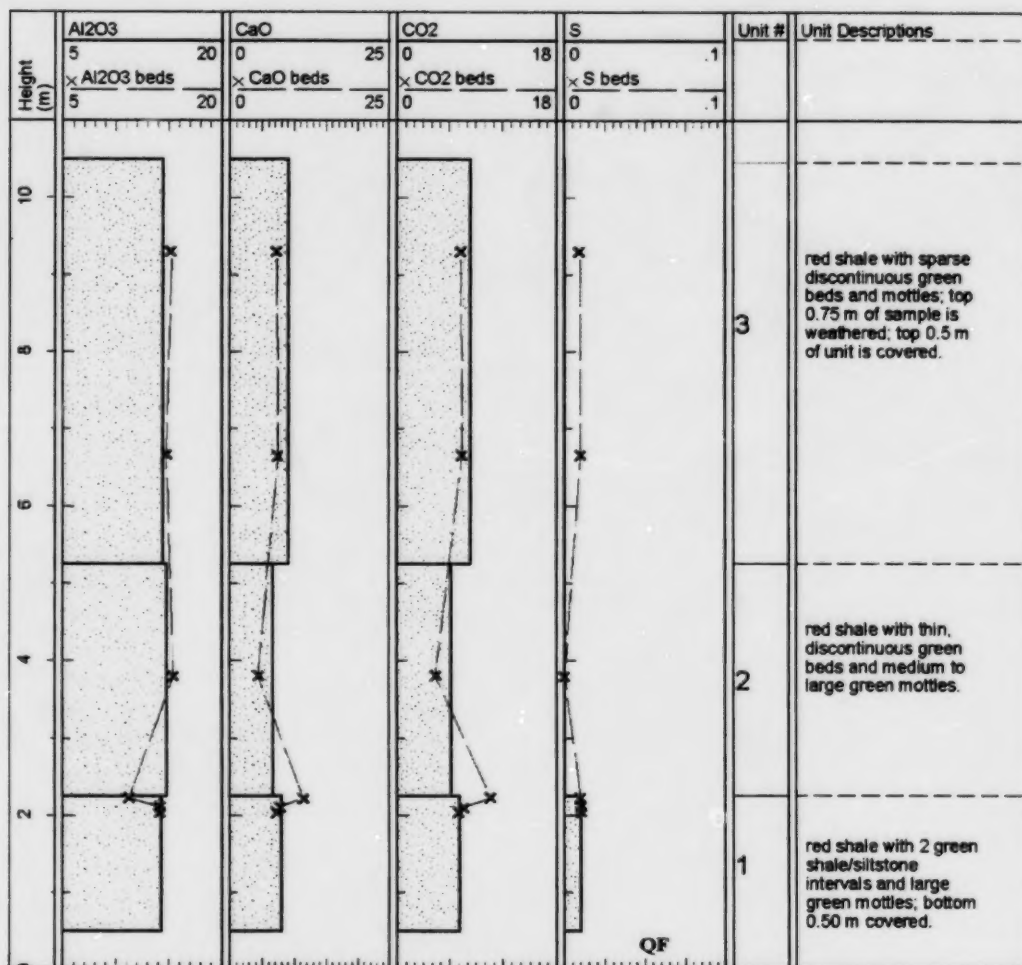


Figure 16: Geochemical and lithologic unit profile of Queenston Formation exposed at the A.C. Martin Quarry (00DKA-006). Only profiles of selected elements are presented here; the complete geochemical data sets are presented in Appendices 4 and 5. Lithologic units are more thoroughly described in Table 5 of Appendix 8. Bars represent composite values and X's connected with dashed lines represent bed sample values. All elemental concentrations are in weight percent (wt%). QF = quarry floor.

CHELTENHAM QUARRY

The Cheltenham Quarry (OGS station 00DKA-003) is located southwest of the Village of Cheltenham, in the Regional Municipality of Peel, on the west side of Peel Road 1, north of Peel Road 9 (Table 8; Figures 1 (back pocket) and 2). Guillet (1967) reported that dry-pressed brick were produced at Cheltenham since 1912 and that the plant and quarry had closed by 1965. The quarry was re-opened in recent years by Brampton Brick Ltd. to supply their new brick plant in the north end of Brampton.

In June 2000 the Cheltenham Quarry was roughly 200 m by 267 m wide and was being developed from southeast to northwest. The main quarry floor was located in the south end of the quarry in the vicinity of the sump pond. The quarry floor ramped up to the northwest, such that the floor in the presently active area is approximately 4 m above the main quarry floor. The section measured for this study included the southeast sump/ramp wall face, a drainage ditch leading westward from the sump pond to the southern face, and up the middle of the south face.

The Cheltenham Quarry exposes a total thickness of 22.95 m of Queenston Formation, which was subdivided into 6 units. The active interval or working face in June 2000 consisted of only the uppermost 21.40 m or the top 3 units. Units 1 and 2 are exposed in the sump section (unit 1 extends below the main quarry floor). Unit 2 is also exposed up the drainage ditch. Unit 3 is the covered interval between the drainage ditch and the south face. Units 4, 5 and 6 are exposed in the south face (i.e., the working face). Descriptions of the units are presented in Table 6 of Appendix 8, and are summarized in Figure 17, where they are presented with corresponding plots of selected major and minor element contents.

In this quarry the Queenston Formation consists mainly of red shale with subordinate, thin, mostly discontinuous, light green shale to fine-grained sandstone beds. Unit 1 consists of green and red sandstone beds. Unit 2, consists mainly of red shale in the basal 1.35 m, overlain by red shale with variable amounts of red and green siltstone, locally abundant small gypsum nodules and rare thin sub-horizontal gypsum seams. Unit 3 is covered. Unit 4 consists of red shale with some green mottles and laterally discontinuous green beds up to 25 cm thick, and small gypsum nodules. This unit is capped by 2 green beds up to 25 cm thick, with small scale cross-lamination. Unit 5 comprises most of the active quarry section (or working face) and consists of red shale, with minor thin to thick green shale beds and scattered small green mottles. Unit 5 is capped by a laterally persistent thin, green, hard bed. The uppermost unit, unit 6, is very similar to unit 5 except that the uppermost 1.4 m is weathered.

Composite samples were taken of all units except unit 3 and the upper part of unit 2. Data from these composite samples are presented in Appendix 4 and summarized in Table 15.

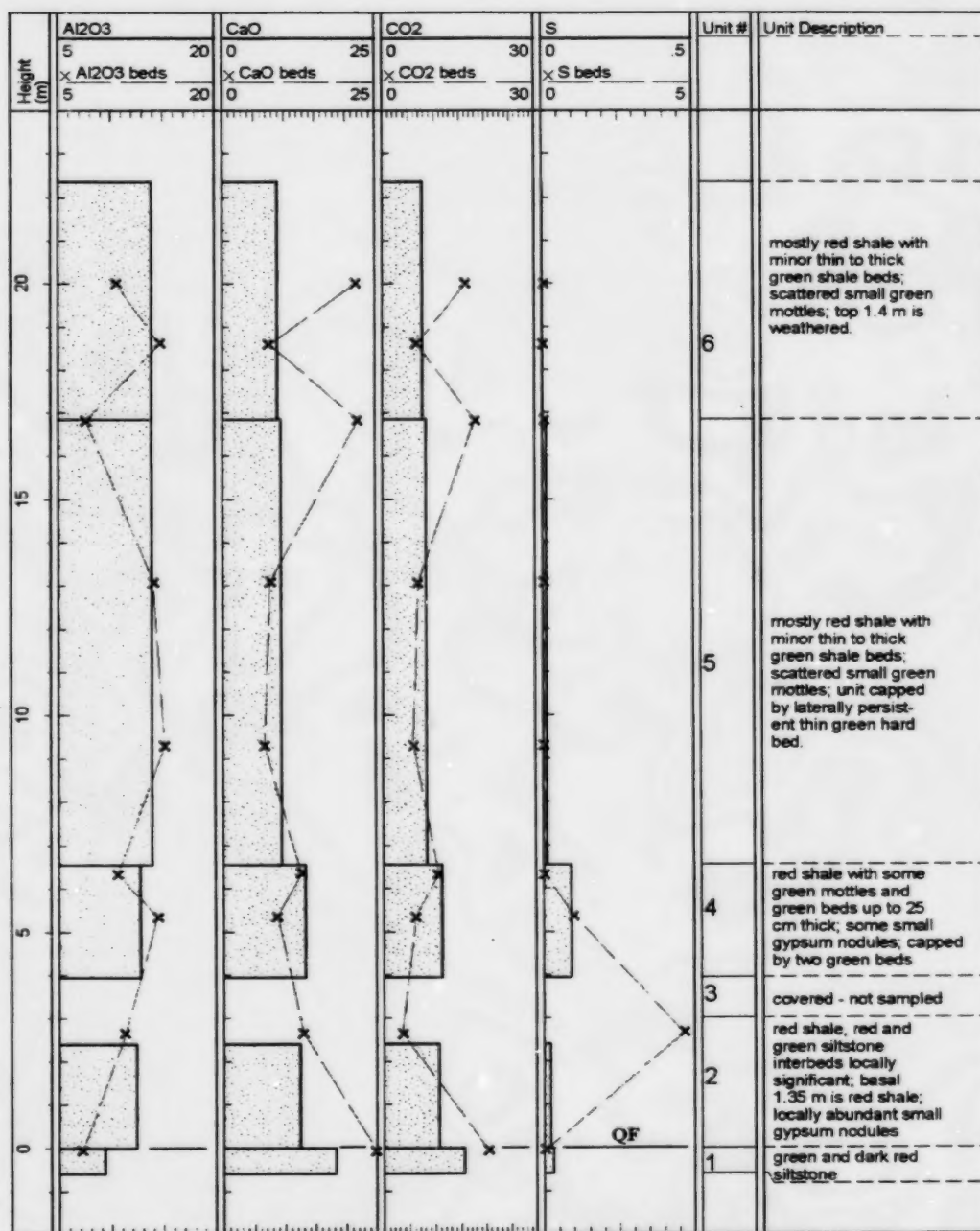


Figure 17: Geochemical and lithologic unit profile of Queenston Formation exposed at the Cheltenham Quarry (00DKA-003). Only profiles of selected elements are presented here; the complete geochemical data sets are presented in Appendices 4 and 5. Lithologic units are more thoroughly described in Table 6 of Appendix 8. Bars represent composite values and X's connected with dashed lines represent bed sample values. All elemental concentrations are in weight percent (wt%). QF = quarry floor.

Table 15: Elemental ranges and weighted averages (from 5 composite samples) for Cheltenham Quarry and for the present working face (w.f.) of the quarry (n=3). See Appendix 4 for the complete data set.

analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
weighted average	47.43	13.45	0.11	3.39	10.33	0.21	3.91	0.14	0.67	5.51	14.23	99.37	8.94	0.02
minimum	42.77	9.28	0.10	2.98	8.82	0.16	2.90	0.14	0.55	3.32	13.50	98.92	7.66	n.d.
maximum	48.58	13.91	0.14	3.55	18.19	0.52	4.11	0.18	0.69	5.83	18.63	99.60	15.50	0.09
w.f. weighted average	47.79	13.73	0.11	3.45	9.81	0.18	4.02	0.14	0.68	5.64	13.85	99.39	8.52	0.02
w.f. minimum	44.28	12.73	0.10	3.20	8.82	0.16	3.56	0.14	0.61	5.06	13.50	98.92	7.66	n.d.
w.f. maximum	48.58	13.91	0.11	3.55	13.26	0.20	4.11	0.15	0.69	5.83	15.76	99.60	11.23	0.09

Guillet (1967) reported an average CO₂ content of 8.27 % for the working face, which at that time was 13.10 m high. He also reported that test briquettes made from this shale burned from light brown to a salmon-brown colour. The average CO₂ of the present working face is similar (cf. 8.52 % in Table 15) and the present through-body brick colour is salmon brown (C. Sacilotto, Brampton Brick, personal communication, 2001).

DISCUSSION OF QUARRY INVESTIGATIONS

One of the criteria used to evaluate shale resource potential is carbonate content. It is reported (e.g., Guillet 1967) that as carbonate content increases, brick colours lighten from red to yellow or buff. Histograms of CO₂ content in composite samples from each quarry (Figure 18) illustrate the range of carbonate content within and among the quarries. Average CO₂ contents for all the quarries studied, except the Burlington Quarry, are below 10 % (see Tables 9 through 15). Samples from the Burlington Quarry, which is reported to produce yellow or buff bricks, have CO₂ contents ranging from 9.98 to 15.60 %, with an average of 14.20 % (Table 10). Thus, in evaluating potential shale resources for the Queenston Formation, a cut-off of approximately 10 % CO₂ may be used to differentiate between shale likely to produce red bricks and that which is likely to produce yellow bricks.

Gypsum is present in 3 of the 6 presently active quarries: Burlington, Aldershot and Cheltenham. Therefore, it appears that gypsum is restricted to those quarries located in the middle to upper middle parts of the Queenston Formation. Average sulphur (S) contents for quarries containing gypsum range from 0.02 to 0.06 %, with individual composite sample values of up to 0.18 % sulphur. Average S contents for quarries with no visible gypsum ranged from not detected up to 0.01 %.

Due to their relatively narrow stratigraphic extent and their geographically restricted distribution, quarry sections give an incomplete picture of the stratigraphic and regional

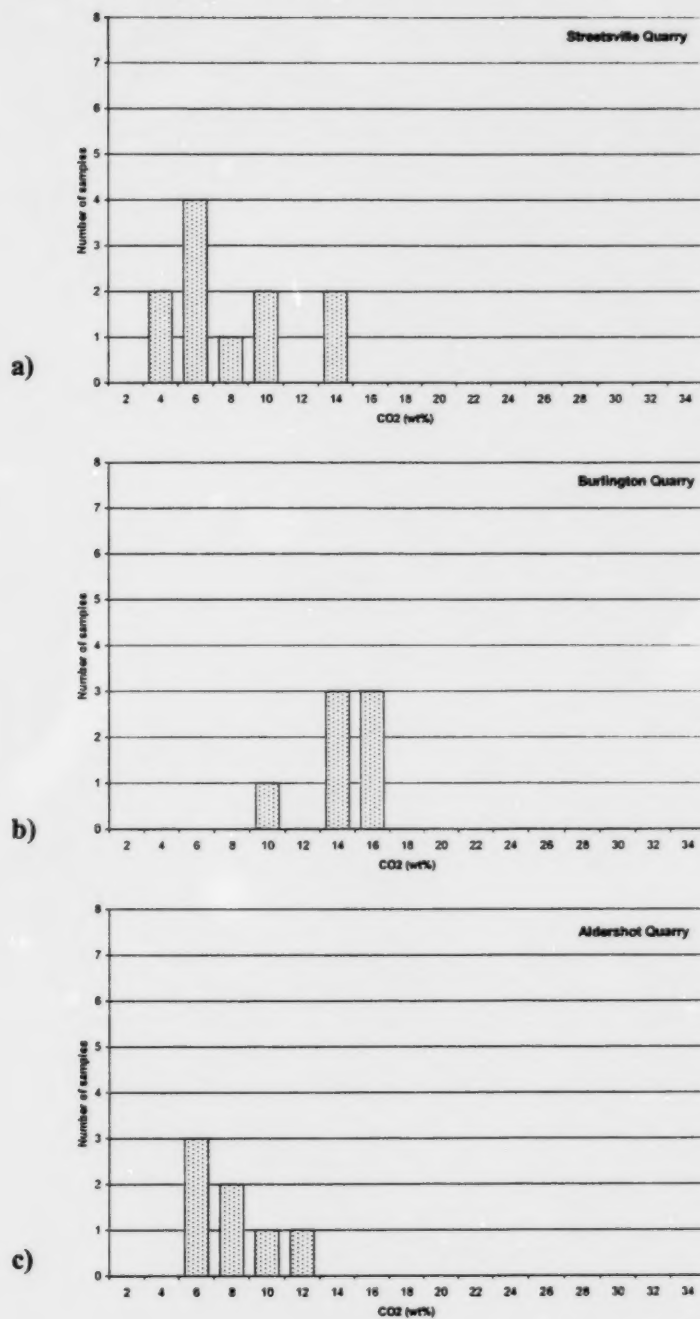


Figure 18: Histograms of CO₂ content in composite samples from Queenston Formation quarries. a) Streetsville Quarry, b) Burlington Quarry, c) Aldershot Quarry.

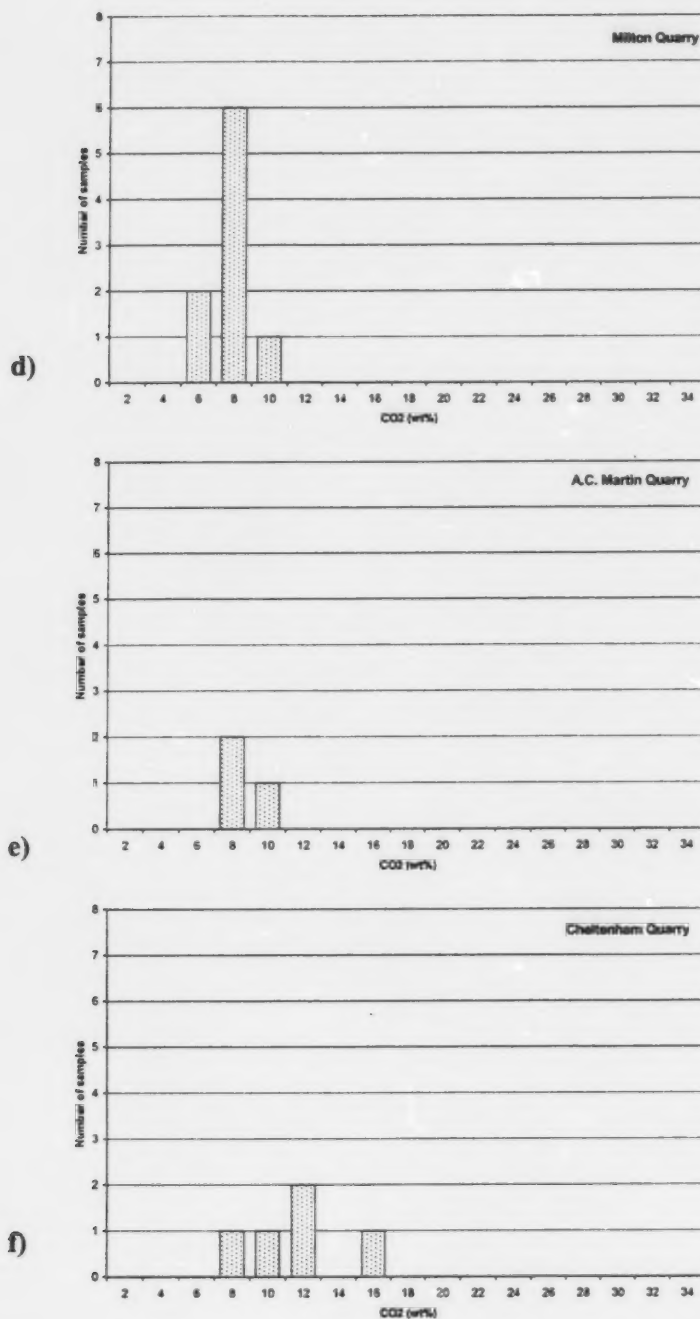


Figure 18 cont'd: Histograms of CO₂ content in composite samples from Queenston Formation quarries. d) Milton Quarry, e) A.C. Martin Quarry, f) Cheltenham Quarry.

variability of the Queenston Formation. A more complete characterization is possible with drill holes which can penetrate thicker, if not complete, intervals of the formation.

Results of the 2000 Shale Drilling Program

As part of this project 10 drill holes were cored in the late summer and early fall of 2000. Drill hole locations are plotted in Figures 1 (back pocket) and 3 and listed in Appendix 9 (they are also listed by station number in Appendix 1). A summary of drilling results is presented in Table 16 (modified from Table 39.1 in Armstrong 2000).

Table 16: Summary of Ontario Geological Survey 2000 drill program results (modified from Armstrong 2000).				
Drill Hole Number	OGS Mapping Station Number	Overburden Thickness (m)	Total Depth Drilled (m)	Bedrock Stratigraphy (formations)
OGS-00-A1	00DKA-045	4.65	35.58	Queenston
OGS-00-A2	00DKA-046	4.27	34.87	Queenston
OGS-00-A4	00DKA-047	7.46	38.48	Queenston
OGS-00-A6	00DKA-048	6.02	37.03	Queenston
OGS-00-A8	00DKA-049	13.94	29.36	Queenston
OGS-00-A10	00DKA-050	15.35	24.76	Queenston
OGS-00-B1	00DKA-051	8.46	55.22	Queenston
OGS-00-B4	00DKA-052	10.59	29.26	Queenston, Georgian Bay
OGS-00-C1	00DKA-053	0.76	75.13	Manitoulin, Queenston, Georgian Bay
OGS-00-C2	00DKA-054	0.00	48.94	Queenston

Six of the holes (the A-series drill hole numbers) were drilled in the southern part of the outcrop belt, in the Regional Municipalities of Halton and Peel. Two holes (the B-series drill hole numbers) were drilled in the central part of the outcrop belt, in Dufferin and Simcoe Counties. And the last 2 holes (the C-series drill hole numbers) were drilled in the northern part of the outcrop belt, in Grey County.

The drill cores provided unweathered material for geochemical analysis and for detailed examination of the lithologic and sedimentological character of the Queenston Formation. Lithologic units were defined in each core based primarily on presence and abundance of non-red shale constituents (i.e., light red and green siltstone and sandstone, limestone and green shale) and on the presence or absence of gypsum nodules or seams. Non-red shale constituents were collectively referred to as "coarse beds" and the percentage of coarse beds within each unit was determined and used for graphical presentation of lithologic character (Figures 19 to 27). Coarse beds are analogous to the informal term "hard beds" commonly used in descriptions of outcrops.

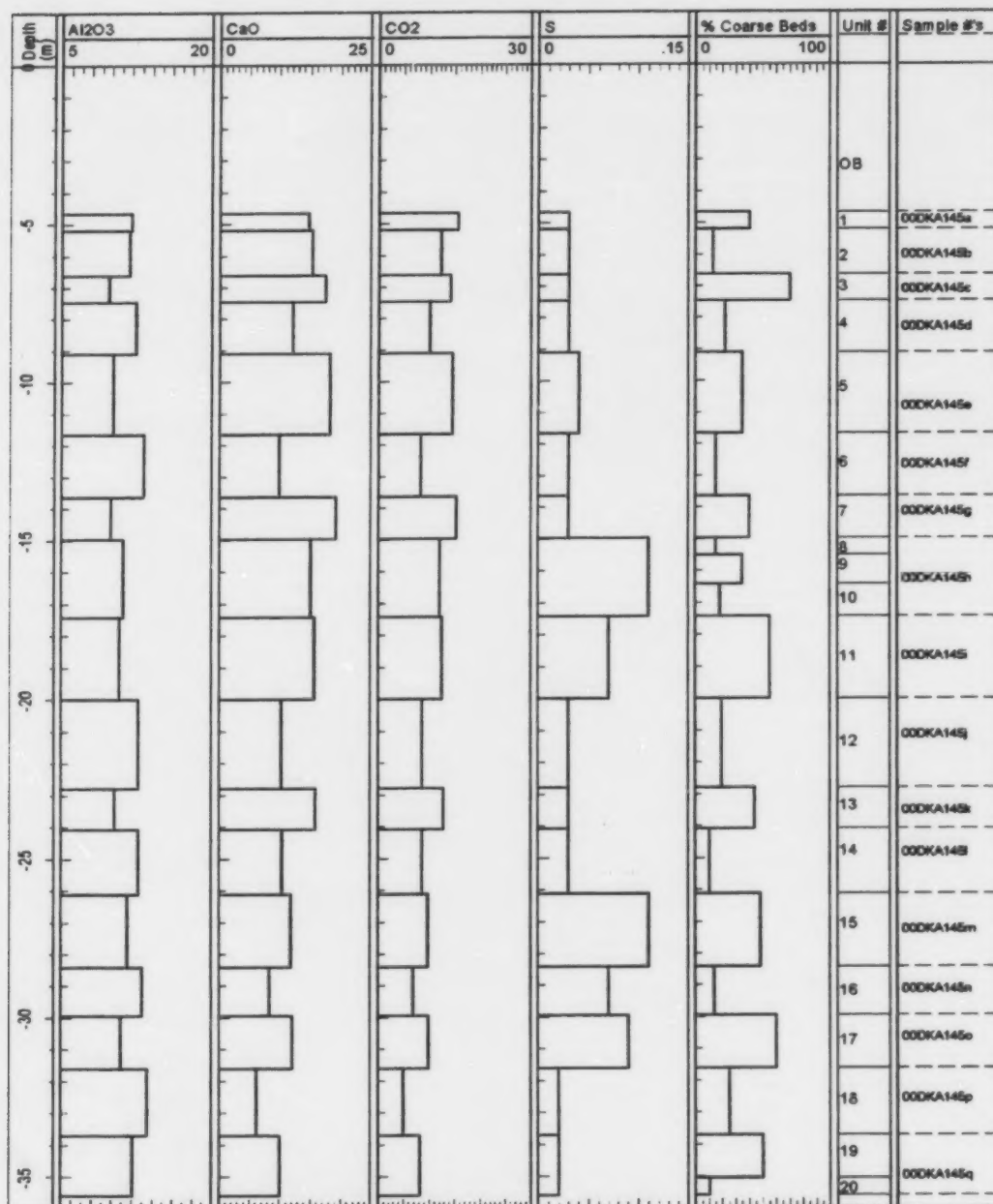


Figure 19: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A1 (00DKA-045). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intra-clastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

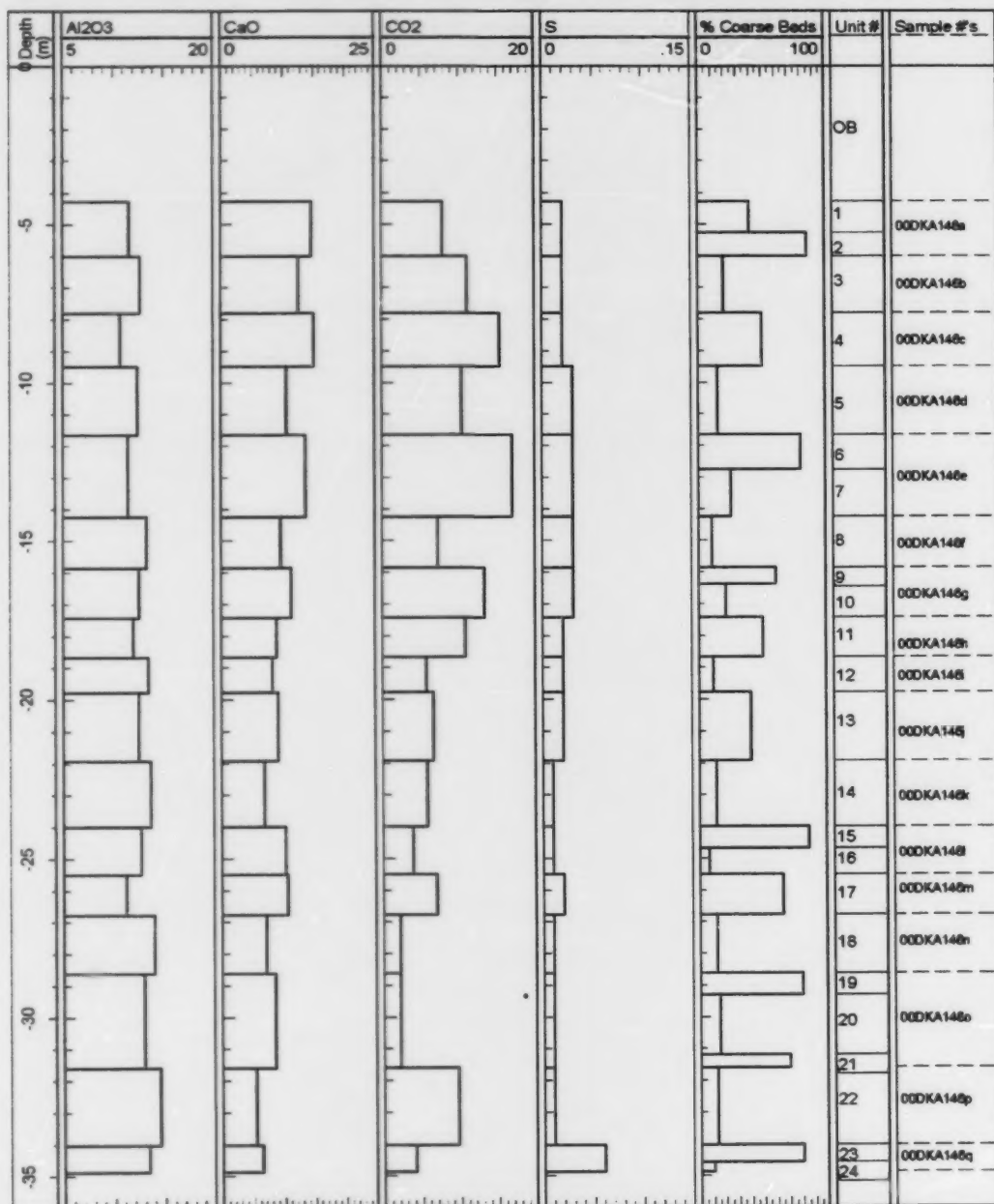


Figure 20: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A2 (00DKA-046). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intra-clastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

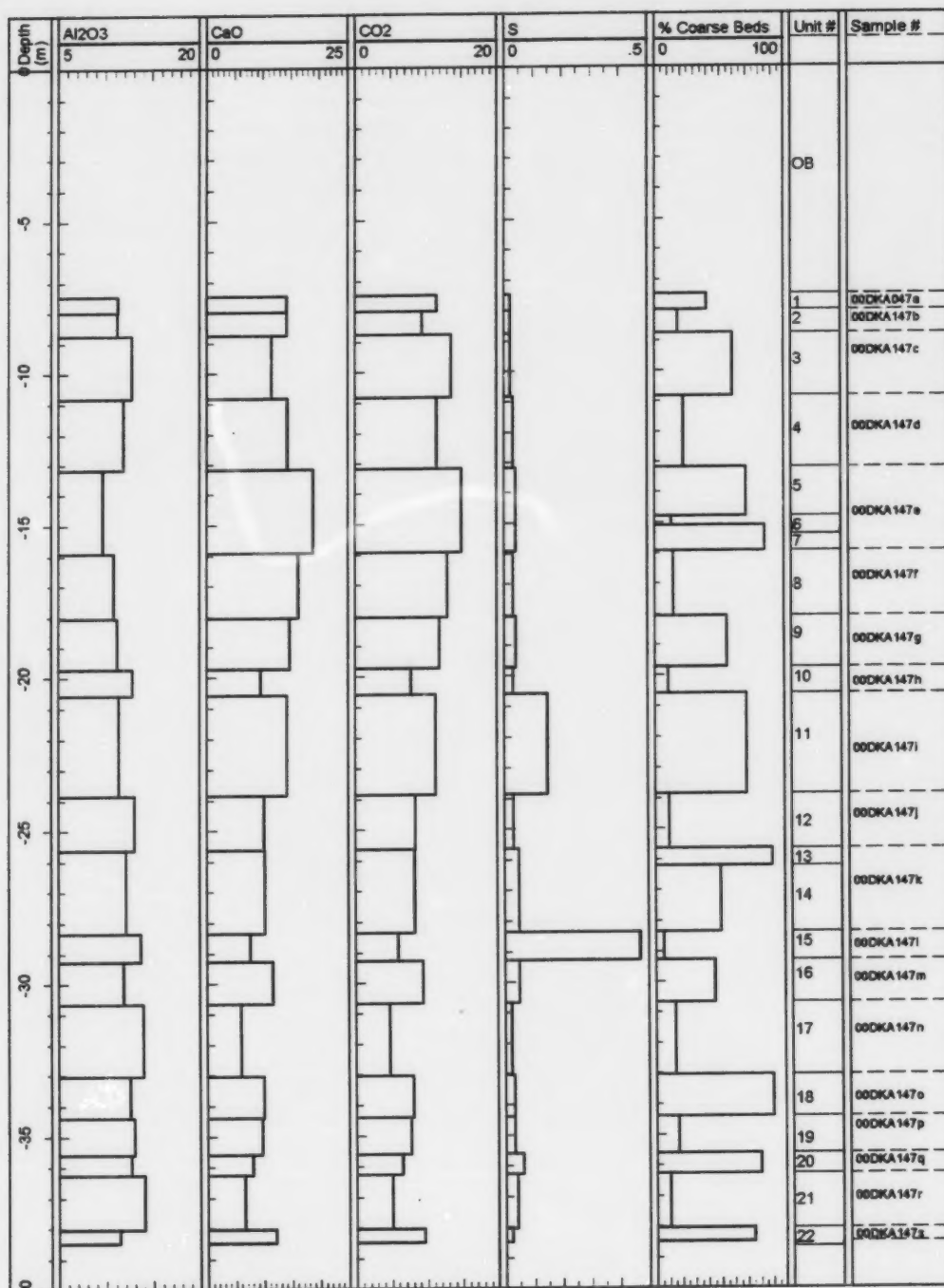


Figure 21: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A4 (00DKA-047). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

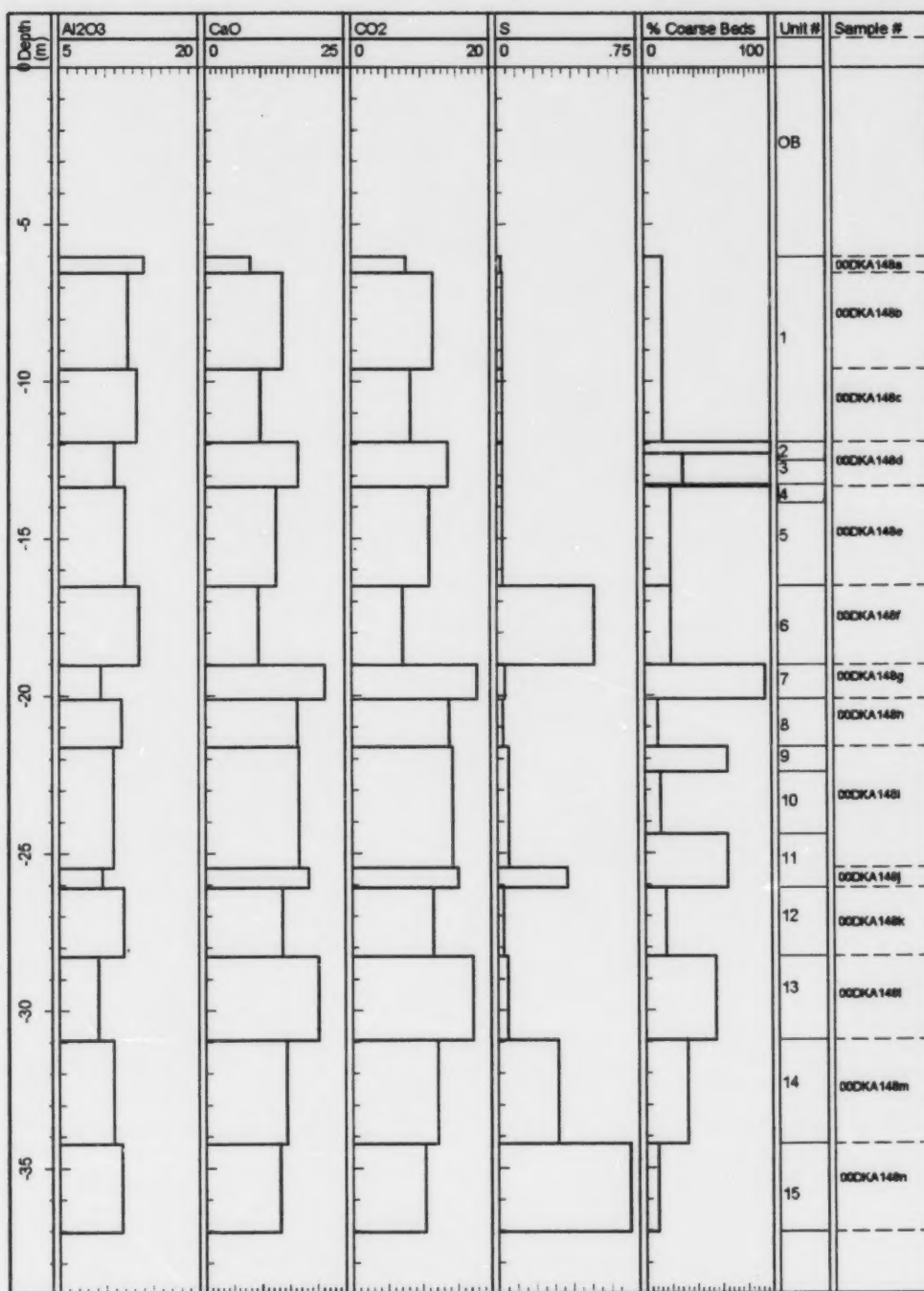


Figure 22: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A6 (00DKA-048). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

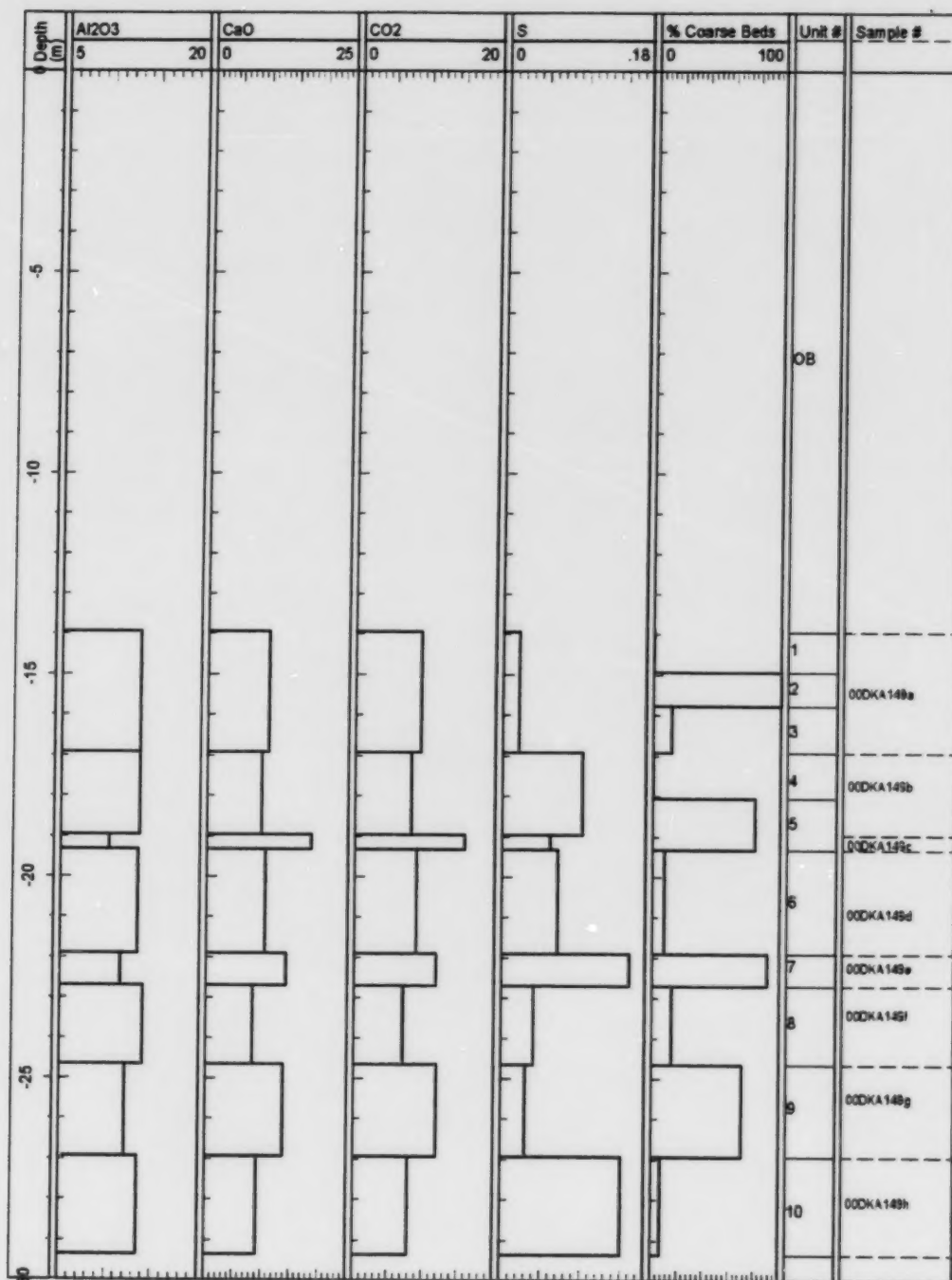


Figure 23: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A8 (00DKA-049). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

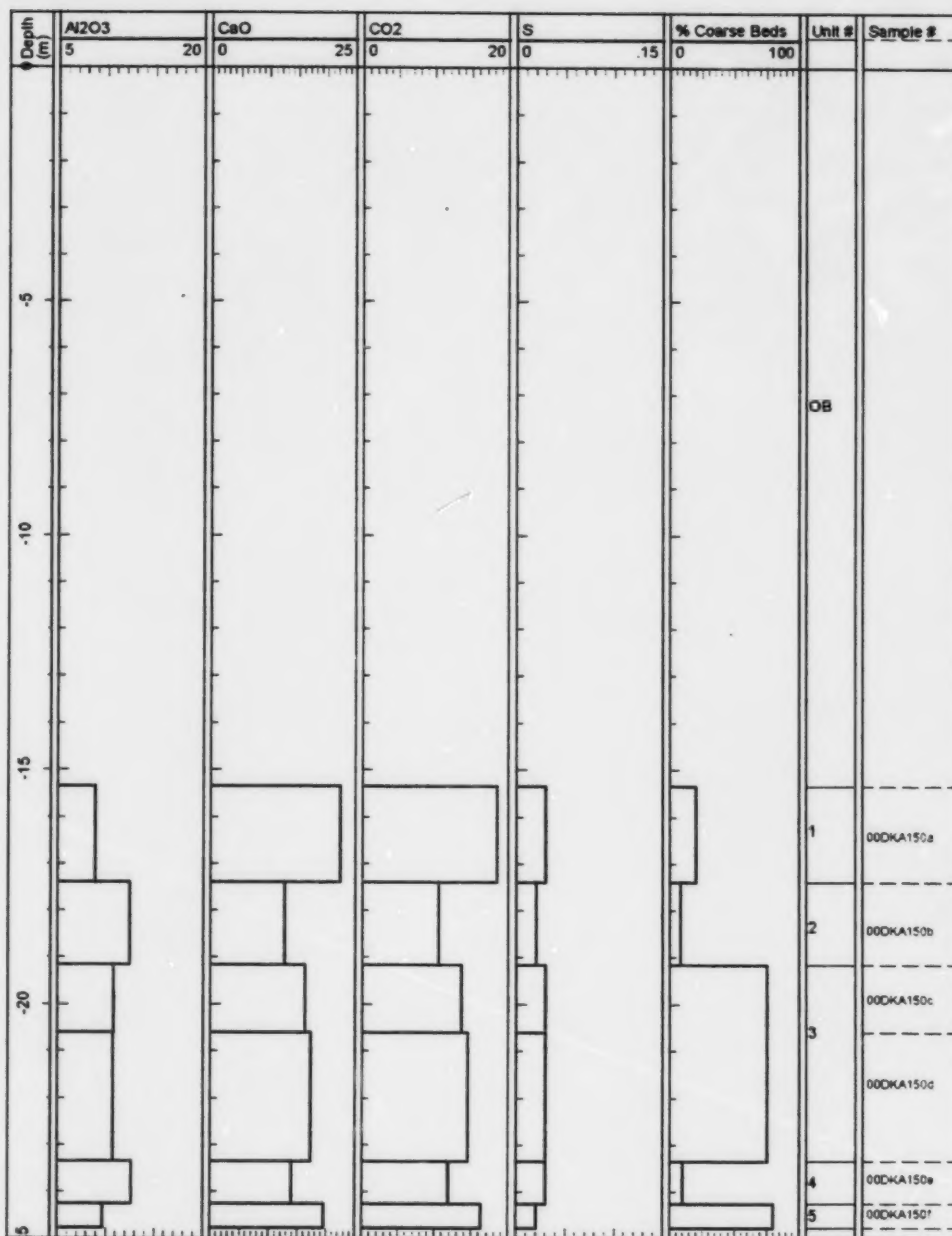


Figure 24: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-A10 (00DKA-050). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

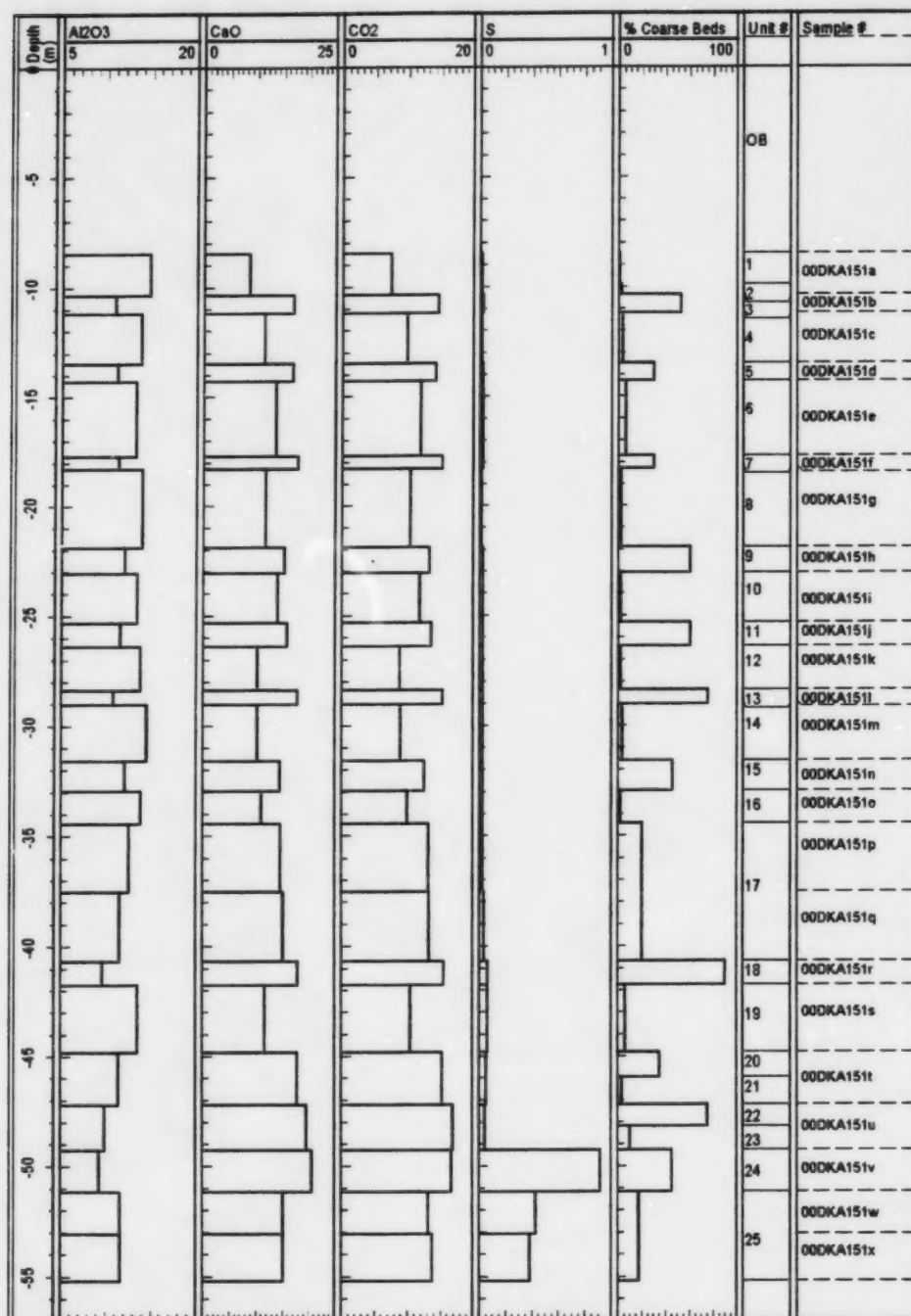


Figure 25: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-B1 (00DKA-051). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

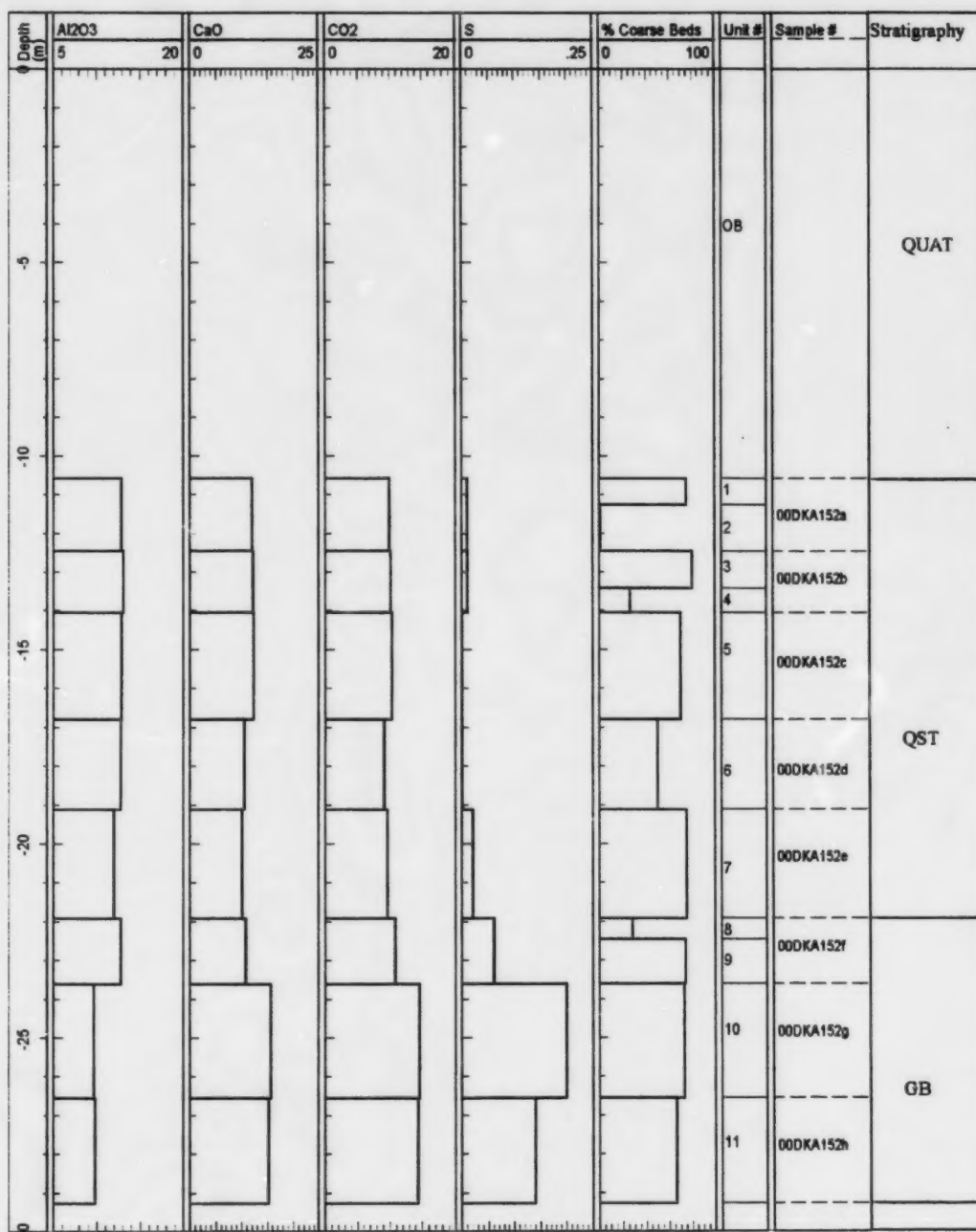


Figure 26: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-B4 (00DKA-052). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Stratigraphy is noted in the column on the right (GB=Georgian Bay Formation, QST=Queenston Formation and QUAT=quaternary overburden). Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%). OB = overburden.

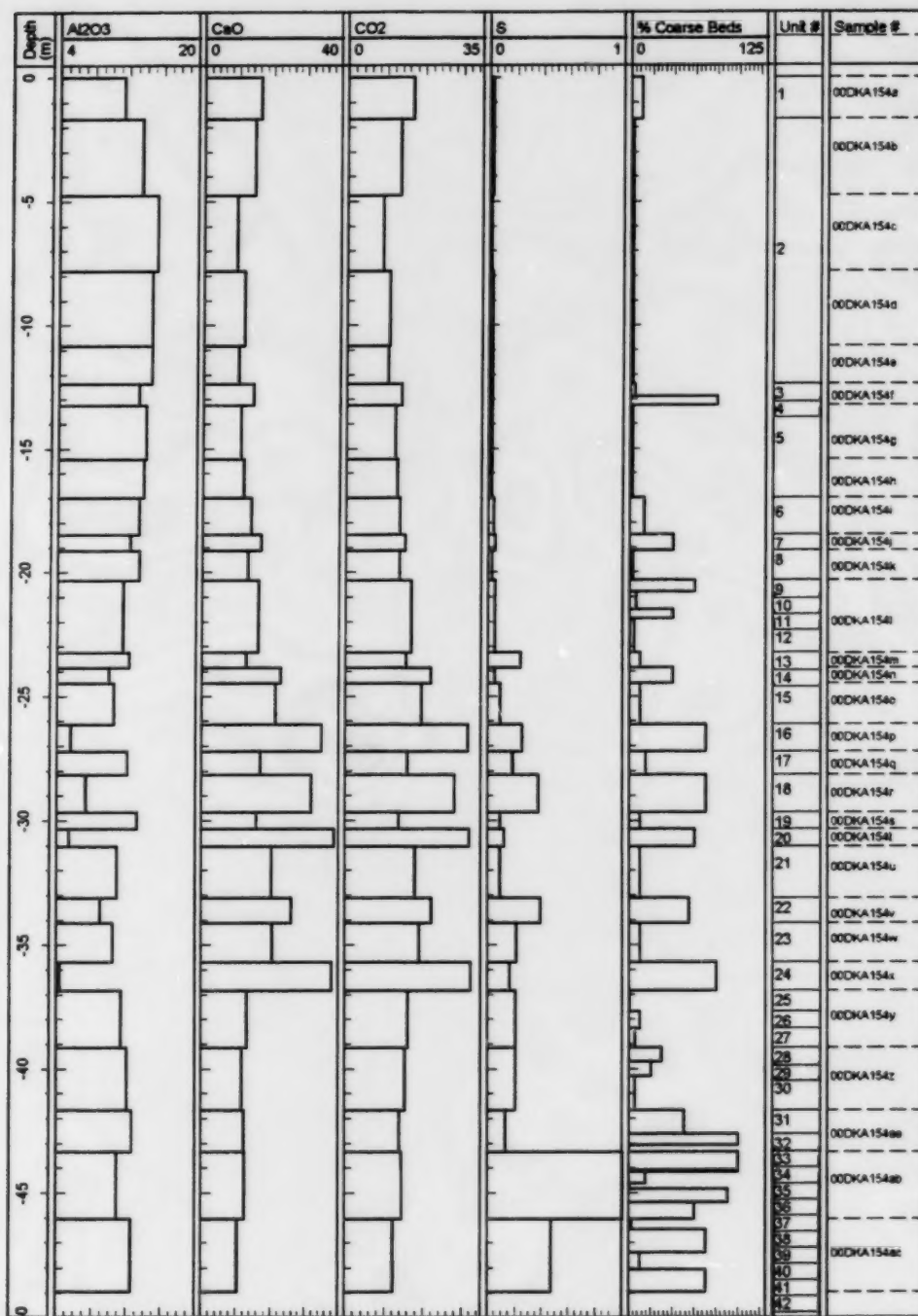


Figure 27: Geochemical and lithologic unit profile of Queenston Formation in drill hole OGS-00-C2 (00DKA-054). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendix 4. For descriptions of lithologic units, see corresponding sample descriptions in Appendix 2. Bars represent elemental or % coarse bed contents over continuous sample intervals. "Coarse beds" include red or green siltstone and fine-grained sandstone beds, shale pebble or intraclastic beds, limestone beds and green shale. All elemental concentrations are in weight percent (wt%).

Composite samples of the cores consist of continuously sampled half cores (split longitudinally). Lithologic units were used to constrain composite sample intervals. Descriptions of units can be found in the corresponding composite sample descriptions in Appendix 2. Due to time constraints drill core OGS-00-C1 was not continuously sampled. Instead, short ~10 cm long bed samples were systematically obtained every ~3 m down the core. These bed samples are described in Appendix 3 and the data from this core are presented in Appendix 5. Vertical profile plots of selected elements, percentage coarse beds, and the distribution of units and samples within each of the 10 cores are presented in Figures 19 through 2.

Subsurface data was also afforded by 2 previously drilled holes: NF#33 (assigned OGS station number 00DKA-043) drilled by Ontario Hydro (now Ontario Power Generation or OPG) at Niagara Falls; and OGS-83-1 (assigned OGS station number 00DKA-001) drilled near Milton by the Ontario Geological Survey (the locations of both are plotted in Figures 1 (back pocket) and 3). The Niagara Falls hole penetrated 139.66 m into the Queenston Formation; it did not intersect the entire thickness. The Milton core intersected the entire thickness of the formation which is 149.65 m at that location. Only one 2000 drill hole, OGS-00-C1 (OGS station 00DKA-053), penetrated the entire Queenston Formation, and at that locality the formation is 69.49 m thick. Bed samples, systematically obtained from these 3 cores, provide a relatively complete stratigraphic profile of the formation at 3 different locations (c.f. vertical profiles of selected elements in Figures 28, 29 and 30). The vertical profile of CO₂ content illustrates the generally more calcareous middle part of the formation. In the north (OGS-00-C1) this is augmented by the occurrence of limestone beds.

The regional geochemical variation within the 2000 drill hole data set illustrates geographic as well as stratigraphic trends in geochemistry. Histograms of CO₂ content of composite samples from each drill hole (Figure 31) shows a general shift to higher CO₂ content in more northern drill cores. For detailed comparisons, however, care must be taken to compare the same stratigraphy. Despite this general increase in carbonate content, there are significant intervals – especially in the upper half of the formation – in the northern cores with CO₂ content between 10 and 15 %, which is in the same range as the Burlington Quarry (c.f. Table 10 and Figure 13). There are few intervals in the northern drill holes where the CO₂ content is less than 10 %, so it is unlikely that a source of material for the manufacture of red bricks can be found in the central or northern parts of the Queenston Formation outcrop belt.

Regional Resource Evaluations

This discussion of shale resource evaluation is subdivided into parts corresponding to 4 geographic regions: 1) Niagara Peninsula; 2) Regional Municipalities of Halton and Peel; 3) Dufferin and Simcoe Counties; and 4) Grey County. These regions generally correspond to the southern, south-central, north-central and northern parts of the Queenston Formation outcrop belt. In each part the discussion will focus on sub-regional

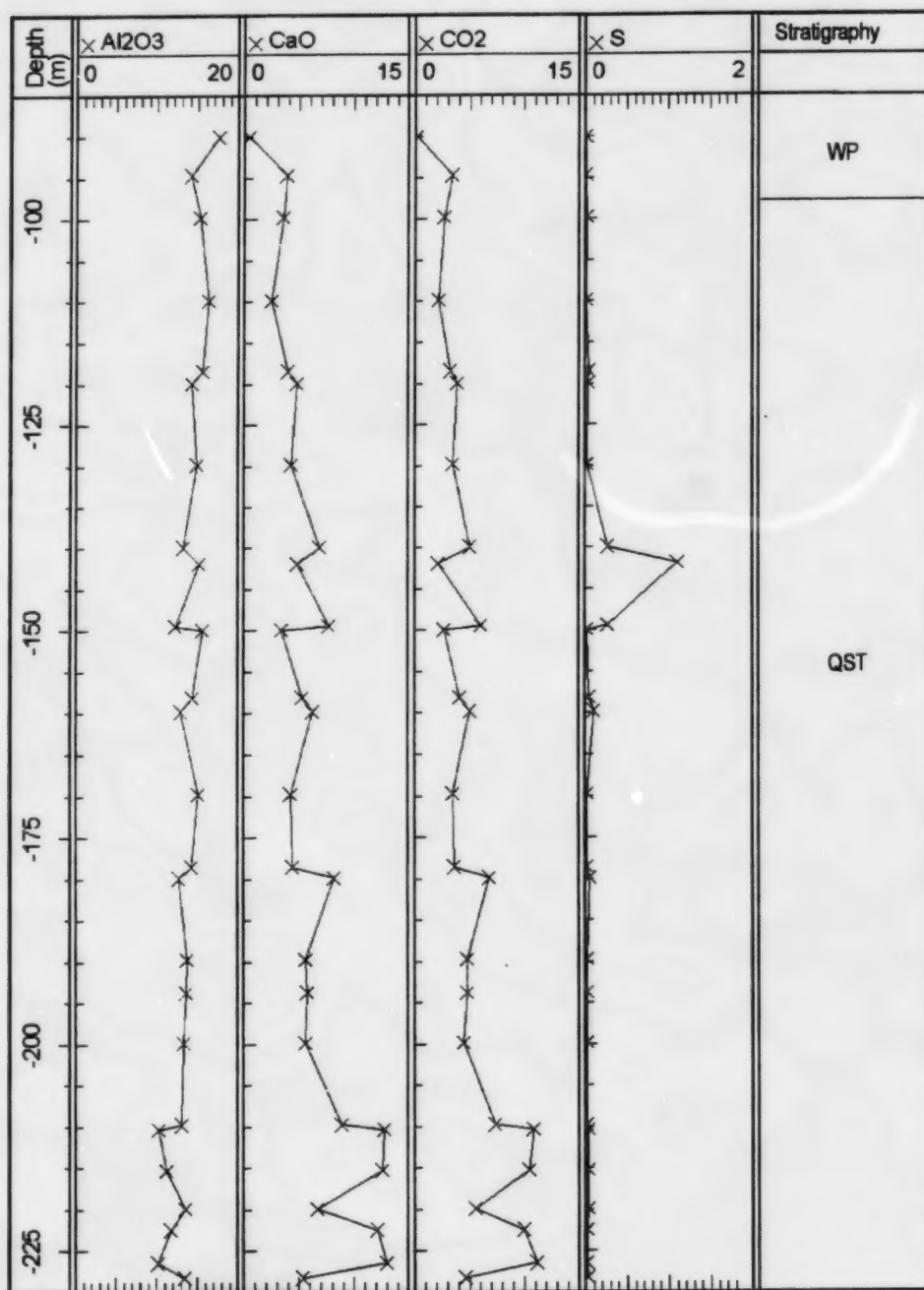


Figure 28: Geochemical profile of Queenston Formation in Ontario Power Generation drill hole NF#33 (00DKA-043). Only profiles of selected elements are presented here; the complete geochemical data is presented in Appendix 5. Samples are described in Appendix 3. Stratigraphy is noted in the column on the right (WP = Whirlpool Formation and QST = Queenston Formation). All elemental concentrations are in weight percent (wt%).

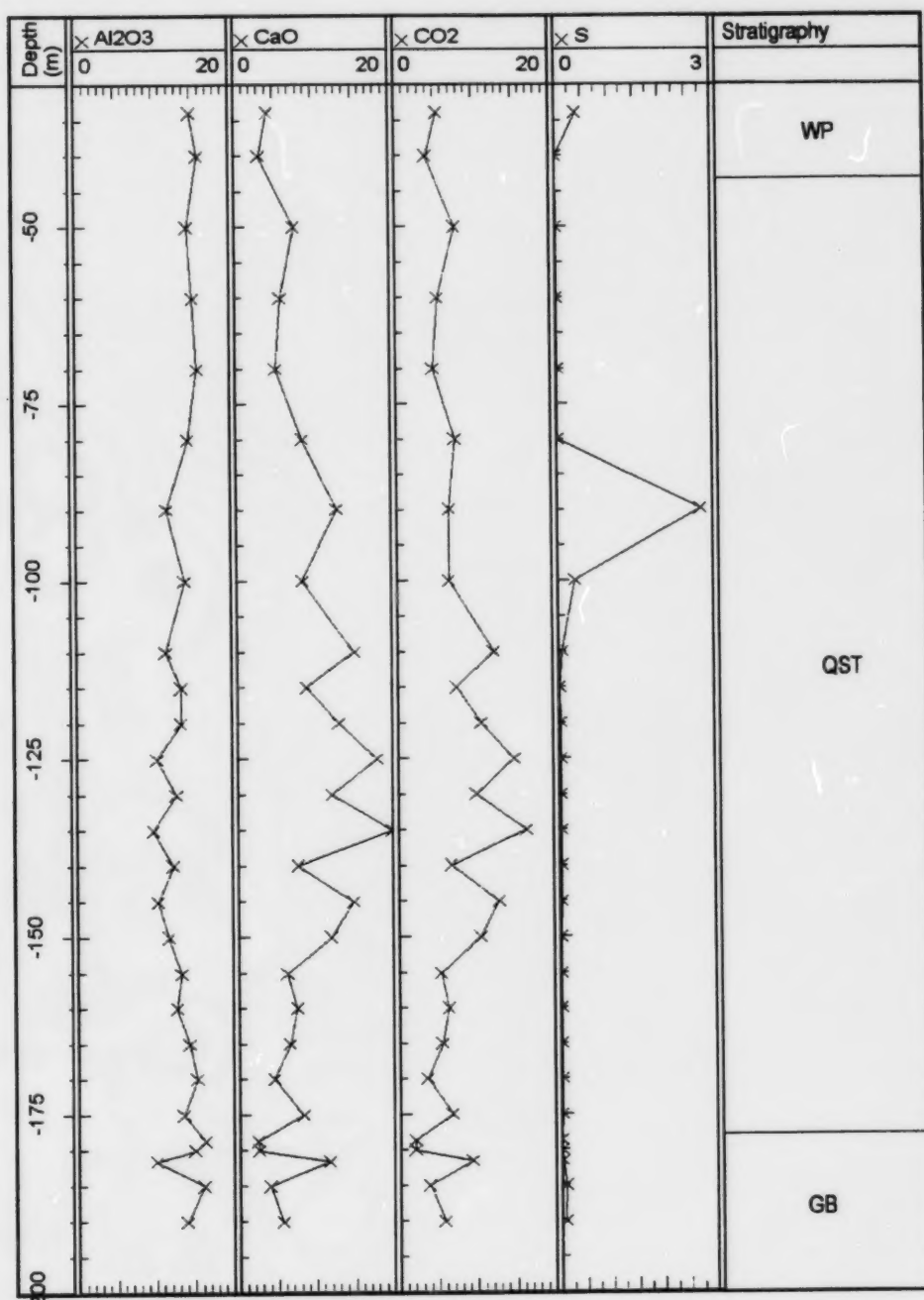


Figure 29: Geochemical profile of Queenston Formation in drill hole OGS-83-1 (00DKA-001). Only profiles of selected elements are presented here; the complete geochemical data set is presented in Appendices 5 and 6. Samples are described in Appendix 3. Stratigraphy is noted in the column on the right (WP = Whirlpool Formation, QST = Queenston Formation and GB = Georgian Bay Formation). All elemental concentrations are in weight percent (wt%).

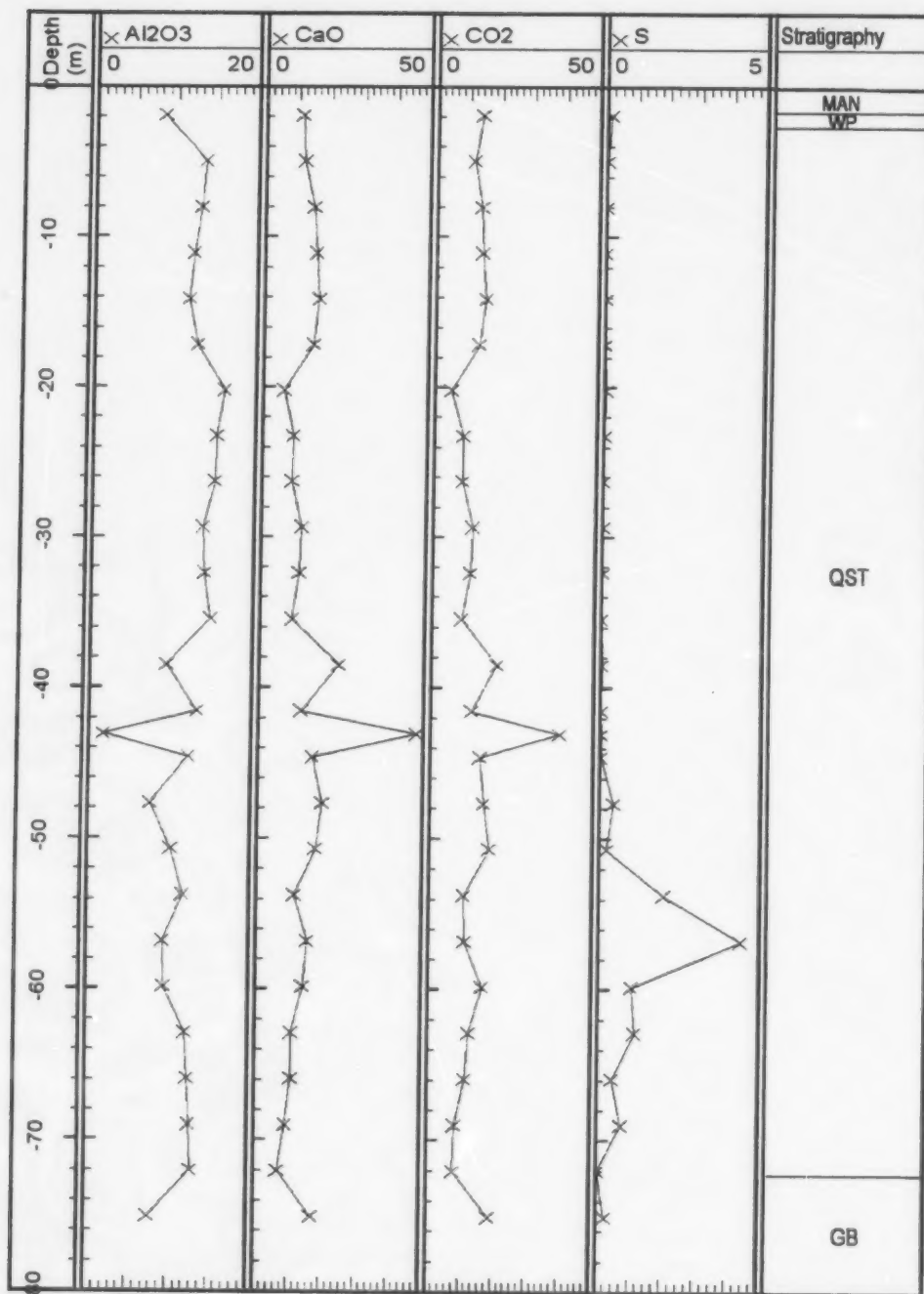


Figure 30: Geochemical profile of Queenston Formation in drill hole OGS-00-C1 (00DKA-053). Only profiles of selected elements are presented here; the complete geochemical data is presented in Appendix 5. Samples are described in Appendix 3. Stratigraphy is noted in the column on the right (MAN = Manitoulin Formation, WP = Whirlpool Formation, QST = Queenston Formation and GB = Georgian Bay Formation). All elemental concentrations are in weight percent (wt%).

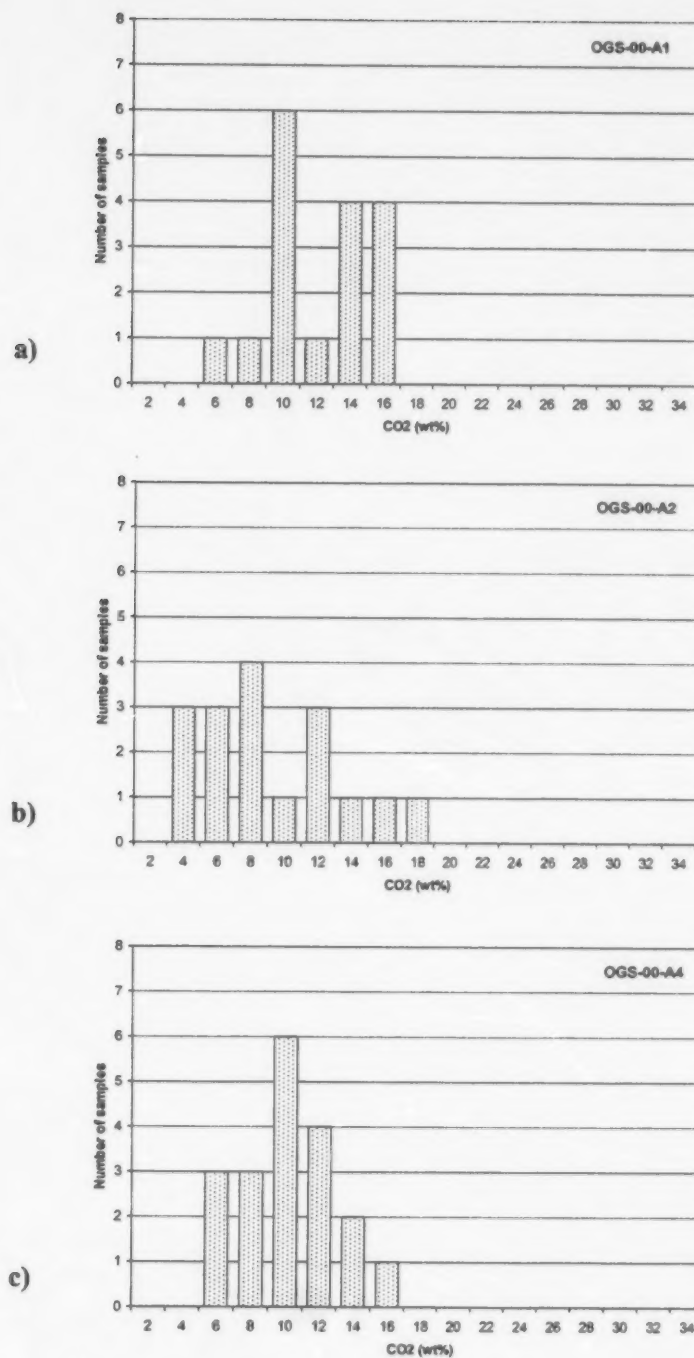


Figure 31: Histograms of CO₂ content in composite samples from the 2000 OGS drill holes. a) OGS-00-A1, b) OGS-00-A2, c) OGS-00-A4.

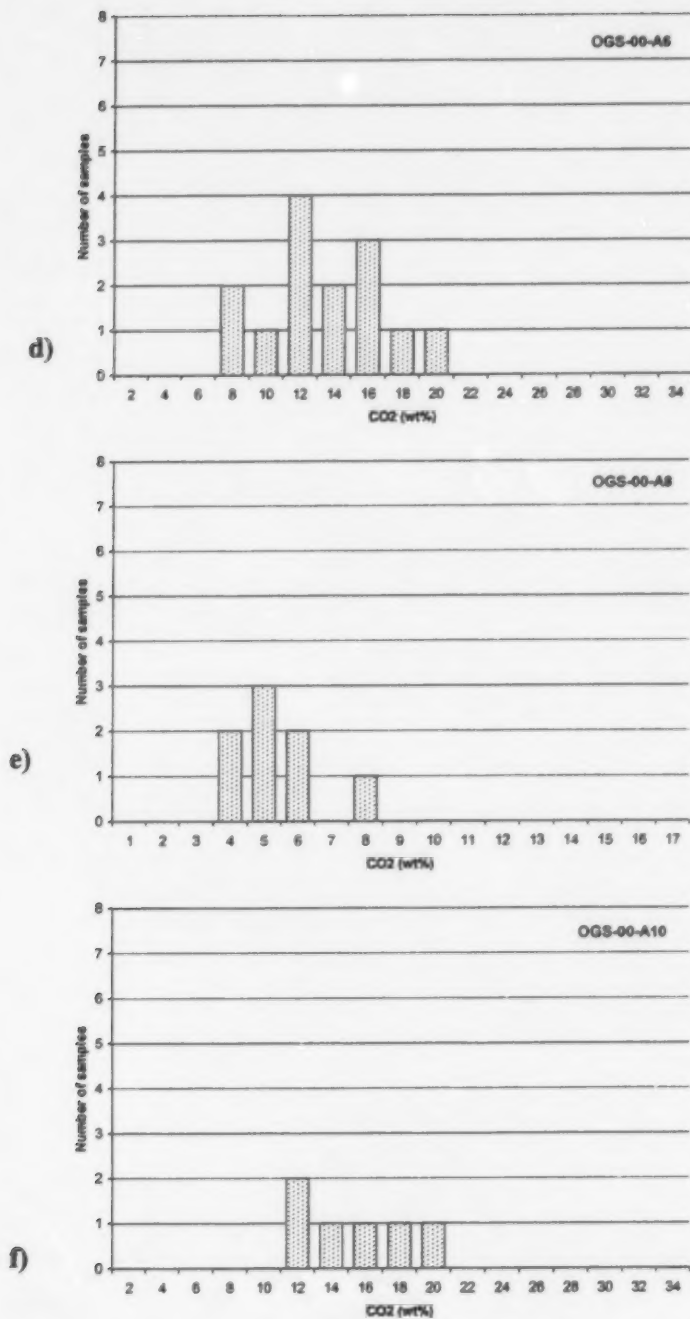


Figure 31 cont'd: Histograms of CO₂ content in composite samples from the 2000 OGS drill holes. d) OGS-00-A6, e) OGS-00-A8, f) OGS-00-A10.

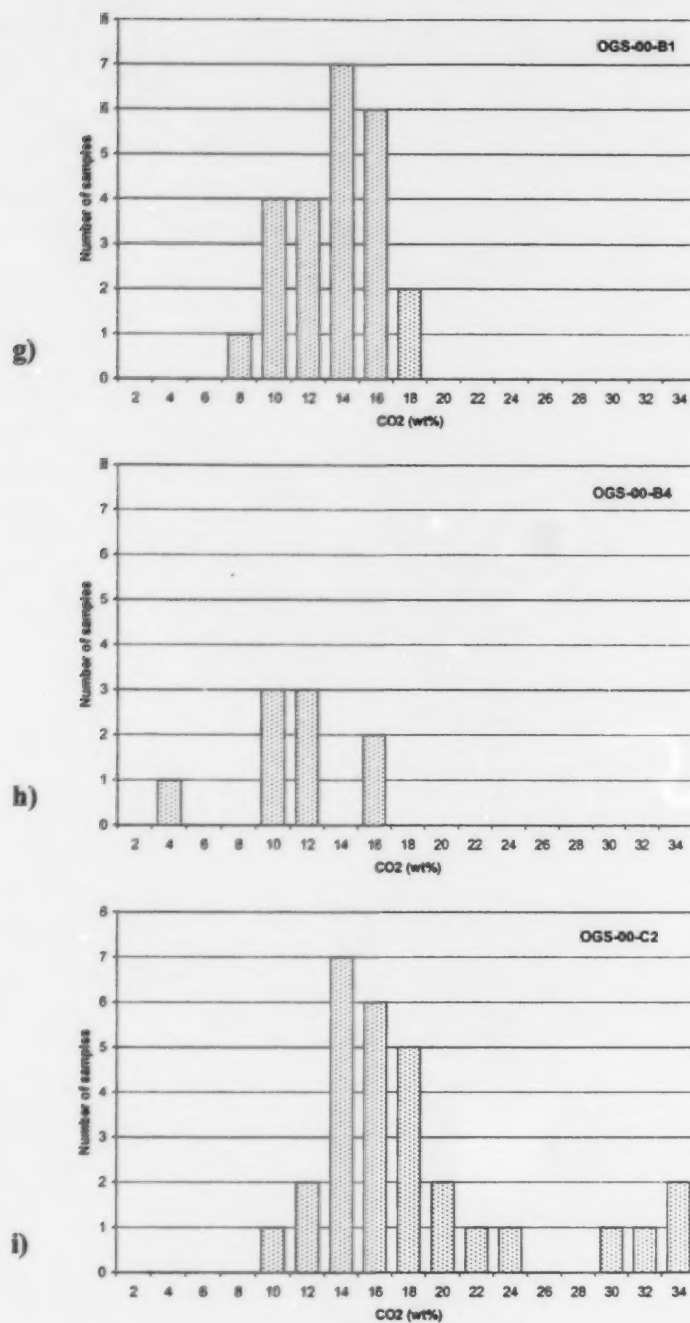


Figure 31 cont'd: Histograms of CO₂ content in composite samples from the 2000 OGS drill holes. g) OGS-00-B1, h) OGS-00-B4, i) OGS-00-C2.

areas of thin drift (less than 8 m) over the Queenston Formation. Drift thickness data are from previously published sources (see Methodology section). Thin drift areas identified in previous publications (e.g., Golders Associates Ltd. and Rowell 1996a, 1996b) are primarily areas with less than 8 m drift covering the Queenston Formation (Figure 4). Areas with less than 1 m drift cover are also plotted in Figure 1 (back pocket). Shale quality for the purposes of this study, is based primarily on geochemical data derived from new outcrop or drill hole data or previously published drill hole data (i.e., Rutka and Vos 1993).

NIAGARA PENINSULA

The Queenston Formation outcrop (and subcrop) belt underlies most of the Niagara Peninsula north of the Niagara Escarpment. Historically, the formation has hosted a number of heavy clay industry operators in the western and central parts of the Niagara Peninsula (e.g., Guillet 1967). In the western part of the peninsula there are large areas which are covered by thin drift (Figure 1 (back pocket)), however, these areas are also overlain by widespread urban development. Areas of thin drift outside of urbanized areas, for example Area 1A (Figures 1 (back pocket) and 4), located between Beamsville and Vineland are, however, typically areas of intense agricultural activity. Guillet (1967) reports a CO₂ content of 3.81% for a 2.44 m section at the (now closed) Grimsby Tile Ltd. plant, located approximately 6 km to the east of Area 1A, but at roughly the same stratigraphic level.

East of Vineland, drift cover is generally thicker than 8 m. One significant area of thin drift, Area 1B (Figures 1 (back pocket) and 4), occurs in the vicinity of St. Davids, south of Niagara-on-the-Lake. The dormant Burnstein Quarry (now owned by Canada Brick Ltd.) is located in this area. This area was tested with an OGS drill hole completed in 1989 (Rutka and Vos 1993). This hole, OGS-89-09, encountered 34.3 m of Queenston Formation strata below 4.7 m of drift. The weighted average CO₂ content calculated for this whole interval is 3.21 % CO₂ (Table 17). Gypsum nodules and seams occur below approximately 20 m depth in this hole (Rutka and Vos 1993).

Table 17: Elemental ranges and weighted averages for 9 samples from drill hole OGS-89-09 (data from Rutka and Vos 1993). See Appendix 7 for the complete data set.

analyte:	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	CO ₂	S	LOI	Total
weighted average	56.64	14.78	6.37	2.59	4.64	0.54	4.07	0.80	0.16	0.09	3.21	0.29	7.79	98.36
minimum	51.60	13.50	5.67	2.20	3.21	0.05	3.64	0.70	0.13	0.08	2.42	0.01	7.10	94.70
maximum	58.70	15.90	7.58	2.82	7.15	0.83	4.54	0.88	0.17	0.11	3.83	1.89	9.30	99.80

Subsurface data for this area is also afforded by a core, NF#33 (also station 00DKA-043), drilled near the Sir Adam Beck Generating Station by Ontario Hydro (now Ontario Power Generation). Bed sample analyses from this hole are summarized in Table 18. A

vertical geochemical profile of this core (Figure 28), indicates that the CO₂ content is less than 10 % for the upper 120 m of the Queenston Formation in this area.

Table 18: Elemental ranges and averages for 27 samples from drillhole NF#33 (00DKA-043). See Appendix 5 for the complete data set and Figure 28 for the vertical profile.

analyte:	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	Total	CO ₂	S
average	56.69	13.76	0.11	2.68	6.25	0.96	3.73	0.15	0.77	5.25	9.43	99.78	5.08	0.09
minimum	50.70	10.22	0.06	2.19	0.44	0.34	2.23	0.13	0.60	3.10	6.43	97.38	0.21	0.01
maximum	60.88	17.62	0.20	3.29	13.03	1.37	5.47	0.17	0.96	7.48	13.83	100.58	11.20	1.11

Outcrop data for the Queenston Formation in the Niagara Peninsula is mainly from exposures of the upper parts of the formation in the vicinity of the Niagara Escarpment. In one of these, the Devil's Punchbowl (00DKA-042), almost 15 m of the Queenston Formation is exposed directly underlying the Whirlpool Formation. The average CO₂ content of the Queenston in this outcrop (n=10) is 3.57 %.

REGIONAL MUNICIPALITIES OF HALTON AND PEEL

The Regional Municipalities of Halton and Peel (Figure 1 (back pocket)) host the widest part of the Queenston Formation outcrop belt, the largest areas of thin drift, and all 6 quarries that are presently utilized by the brick manufacturing industry. These regional municipalities are also areas of rapid and intense urban development and thus access to future shale resources here are threatened. This section is subdivided into discussions of the following sub-regions: Burlington-Oakville, Milton, Georgetown south, Brampton, and Georgetown north.

Burlington-Oakville

A large area of thin drift cover stretches from Burlington east to Oakville and then northeast to Mississauga, roughly parallel to the shoreline of Lake Ontario (Figures 1 (back pocket) and 4). The Burlington and Aldershot quarries and brick plants occur in this area and the Streetsville Quarry occurs in a northeastern extension of this thin drift area in Mississauga. The eastern branch of this thin drift area which extends into Mississauga, east of the Credit River, is now largely urbanized and will not be considered in this report.

The Burlington-Oakville area is the focus of the most intense urban development in this region. The land south of Highway 5 in Burlington and Oakville is essentially urbanized and unavailable for quarry development. Oakville recently proposed to extend its urban zone northward towards the new Highway 407 (Figure 1 (back pocket)). The only parts of the Burlington-Oakville thin drift area that are not covered by urban development, or soon to be zoned urban, are 2 lobes which extend to the north. The Oakville lobe (Area 2A) extends north of Highway 407 in the Sixteen Mile Creek and related tributary

valleys. The Burlington lobe (Area 2B) extends north of Highway 5 generally along the Bronte Creek valley and into southern Milton.

Area 2A was tested with 3 drill holes: OGS-00-A1 (00DKA-045), OGS-00-A2 (00DKA-046), and OGS-00-A4 (00DKA-047). These cores were drilled to total depths of 34 to 38 m and encountered 4.27 to 7.46 m of drift cover (Table 16). The CO₂ content of the top 14 to 17 m of Queenston shale in all 3 of these cores ranges from approximately 10 to 15 % (see Figures 19, 20 and 21), and they are thus, at least geochemically, similar to the Burlington Quarry section (c.f. Table 10).

Area 2B, the Burlington lobe, was not tested in 2000 by drilling. It hosts the proven resource of the Burlington Quarry in the south and extends to the northwest along Bronte Creek valley towards Zimmerman and Mount Nemo. The northern part of Area 2B should be stratigraphically higher than the Burlington Quarry and thus is likely to be less calcareous and may contain less gypsum. It would likely be similar in character to the section exposed at the Aldershot Quarry.

Milton

Two thin drift areas occur in the vicinity of Milton. One, located on the east side of Milton, is the site of past and present (i.e., the Milton Quarry) quarry activity in the Queenston Formation. This area lies partly within the NEC plan area and partly within the urban boundaries of Milton and thus will not be considered further in this report. A large area, Area 2C (Figure 1 (back pocket) and 4), located to the east of Milton was tested by drill hole OGS-89-08 (Rutka and Vos 1993). That hole, located on the west side of the thin drift area unexpectedly encountered over 17 m of drift. A cursory examination of waterwell records in the area suggests that thin drift cover may exist in the eastern part of the originally delineated area. However, Milton recently expanded its urban boundaries and they now cover virtually all except the eastern most part of Area 2C. Results of tests on the OGS-89-08 core (Appendix 7 and Table 19) indicates a relatively low carbonate content in this area.

Table 19: Elemental ranges and weighted averages for 5 samples from drill hole OGS-89-08 (data from Rutka and Vos 1993). See Appendix 7 for the complete data set.

analyte:	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	CO ₂	S	LOI	Total
weighted average	52.19	13.12	5.78	2.76	8.36	0.74	3.59	0.68	0.17	0.10	6.85	0.04	10.86	98.38
minimum	44.30	9.30	3.04	2.32	5.23	0.58	2.48	0.51	0.15	0.08	3.96	0.02	8.40	97.50
maximum	55.50	14.30	6.55	2.90	17.30	0.88	3.97	0.72	0.18	0.14	14.10	0.12	17.20	98.60

Georgetown South

Two areas of thin drift were identified (Golders Associates Ltd. and Rowell 1996a) between Georgetown and Highway 401 (Figure 1 (back pocket) and 4). One of these, Area 2D, is located south of Georgetown and was tested with drill hole OGS-00-A8

(00DKA-049). This drill hole encountered more than 13 m of drift indicating that further evaluation of Area 2D must pay particular attention to re-evaluating drift thickness. This area may be much smaller than previously indicated. With respect to the quality of the shale encountered in this hole, most sample intervals contained less than 10 % CO₂ (Figure 23).

Area 2E, located southeast of Georgetown, straddling Mountainview Road, was tested with drill hole OGS-00-A6 (00DKA-048). At that locality, bedrock was encountered at a depth of 6.02 m and the CO₂ content in the top 13 m of the bedrock ranged from 7.31 to 13.90 %, with a weighted average of 10.26 %. Below 13 m in this hole the weighted average CO₂ content increases to 13.70 %. As with Area 2D, further investigation of Area 2E should include a careful re-evaluation of drift thickness, paying particular attention to surface topography.

Brampton

A large area of thin drift, over the Queenston Formation located in the northeast corner of Brampton, north of the village of Norval, has been identified as a potential shale resource (Vos 1975; Proctor and Redfern 1978; Telford and Narain 1980; Guillet 1983). Most of this area, identified herein as Area 2F (Figure 1 (back pocket) and 4), is either urbanized or zoned urban and the remaining part of this area is currently under review by the City of Brampton. Other areas of thin drift occur in the central and eastern parts of the City of Brampton (Figure 1 (back pocket)) and are not considered further in this report.

Area 2F was tested with a drill hole in 1989, OGS-89-05a, and again in 2000 with drill hole OGS-00-A10 (00DKA-050). Drill hole OGS-89-05a, located in the middle of Area 2F at Mount Pleasant, encountered the Queenston Formation at a depth of 3.05 m (Rutka and Vos 1993). The CO₂ content in this core ranged from 5.45 to 15.00 %, averaging 8.68 % (Table 20) and generally decreased with depth (Appendix 7).

Table 20: Elemental ranges and weighted averages for 10 samples from drill hole OGS-89-05a. See Appendix 7 for the complete data set. Data from Rutka and Vos (1993).

analyte:	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	CO ₂	S	LOI	Total
weighted average	48.72	12.30	5.35	2.43	10.91	0.67	3.38	0.64	0.15	0.10	8.68	0.30	12.54	97.20
minimum	38.20	9.37	4.06	1.55	7.70	0.41	2.55	0.29	0.12	0.08	5.45	0.02	9.90	77.20
maximum	54.00	13.30	6.20	2.79	19.00	0.79	3.82	0.74	0.17	0.12	15.00	3.70	18.20	99.70

Drill hole OGS-00-A10, located in the extreme northwest part of Area 2F, encountered 15.35 m of drift over the Queenston Formation. This indicates that the northwest part of Area 2F may be much smaller (i.e., the drift is thicker) than previously thought. Careful re-evaluation of waterwell and any other reliable data is required to establish tighter outlines of all thin drift areas.

Georgetown North

A long narrow area of thin drift, Area 2G, is located north and west of Georgetown. This area is mostly covered by the NEC plan area, but is also the host to 2 active Queenston shale quarries, the A.C. Martin Quarry and the Cheltenham Quarry. This area also hosts the 'Cheltenham Badlands', a large, eroded outcrop of the Queenston Formation. The shale in this area is stratigraphically located in the upper part of the Queenston Formation and is considered of high quality.

DUFFERIN AND SIMCOE COUNTIES

The Queenston Formation in Dufferin and Simcoe Counties, the central and north-central parts of its outcrop belt, is largely covered by thick Quaternary deposits. Most thin drift areas are located within or immediately adjacent to the NEC plan area.

Dufferin County

Small areas of thin drift are reported in the vicinity of Mono Mills and in Mulmur Township (Figure 1 (back pocket)). Some of these fall within, or immediately adjacent to, the NEC plan area. Those near Mono Mills appear to be mostly restricted to the lower parts of deep valleys and thus do not present an easily accessible resource for quarrying.

An outcrop in the upper Hockley Valley, northeast of Orangeville, exposes 12.90 m of the upper part of the Queenston Formation. Bed samples from this outcrop range from 4 to 14 % CO₂ content, with an average of less than 10%. This outcrop, and most others in this area lie within the NEC plan area.

A relatively large area of thin drift, Area 3A (Figure 1 (back pocket) and 4), is identified at Rosemont, straddling Mulmur, Mono and Adjala townships (MacNaughton et al. 1998; Vos 1975). Rutka and Vos (1993) tested this area with drill hole OGS-89-06 and found that although the area was mapped as being underlain by the Queenston Formation, the Georgian Bay Formation was encountered at a depth of 6.10 m. It is possible that other parts of Area 3A are underlain by the lower part of the Queenston Formation. The carbonate content (as indicated by CO₂ values) of samples from OGS-89-06 is low (CO₂ less than 8%; Appendix 7) in all but the uppermost 2.44 m. Thus, this area may still represent a quality shale resource, regardless of whether it consists of Queenston or Georgian Bay Formation shales.

Thin drift Area 3B consists of 2 small areas in the central part of Mulmur Township west of the village of Mansfield. Outcrops of the Queenston Formation occur on the 15th Sideroad on the hillside adjacent to the Mansfield Ski Resort, on the 1st Line East immediately north of the 15th Sideroad (00DKA-031), and on the 10th Sideroad approximately 6 km west of Mansfield. This general area, bound by the Boyne River valley to the south, the Pine River valley in the north and Airport Road to the east is a high plateau or promontory which appears to be cored by Queenston Formation bedrock

and blanketed with an irregular cover of Quaternary deposits. Queenston Formation shales are exposed on the flanks of the promontory and in creek valleys that cut through the drift cover. The largest area of thin drift is a long sinuous area on the eastern flank of this area.

Drill hole OGS-00-B1 (00DKA-051) located in the west end of this area (above the outcrop at station 00DKA-031), was drilled to a depth of 55 m in order to provide data (Figure 25) for the whole of Area 3B. The top 26 m of bedrock encountered in this hole averaged 10.94 % CO₂, whereas, the lower 20 m averaged 13.84 %. Projecting these results to the east, the increase in carbonate content with depth suggests that the eastern part of Area 3B may be too calcareous for use in brick manufacturing. Testing of the eastern part is recommended to test this hypothesis.

Area 3C straddles the boundary between Dufferin and Simcoe Counties. One small outcrop in this area, located south of Creemore (station 00DKA-030), was examined. Two bed samples obtained there contained 9.07 % and 9.57 % CO₂, respectively. Area 3C lies entirely within the NEC plan area and thus will not be considered further in this report.

Simcoe County

Except for the northern part of Area 3C (see above), there is only one other area of thin drift over Queenston Formation in Simcoe County. This area, Area 3D, is located west of the village of Duntroon (Figure 1 (back pocket) and 4) and for the most part outside the NEC plan area. There are few outcrops in the vicinity of Area 3D, however, an inactive quarry immediately to the west exposes the overlying Whirlpool and Manitoulin formations. Further investigation is required to assess the Queenston shale in Area 3D.

Most of the Queenston Formation outcrop belt in Simcoe County lies within the NEC plan area. An outlier of this formation is mapped at Ten Hill (Figure 1 (back pocket)), north of Creemore. Hole OGS-00-B4 (00DKA-052) was drilled on the north side of Ten Hill (Table 16 and Appendix 9) to determine drift thickness and confirm the presence of the Queenston Formation. This drill hole intersected, beneath 10.59 m of overburden, the basal 13.01 m of the Queenston Formation overlying the Georgian Bay Formation (Figure 26). The average CO₂ content of the Queenston strata in this hole is 9.92 %. Further detailed investigation of the drift thickness in this area is warranted.

GREY COUNTY

There are 5 main areas with thin drift over the Queenston Formation in Grey County (Figures 1 (back pocket) and 4). Area 4A is located along the flanks of the Blue Mountains west of Collingwood and southeast of Thornbury. It lies entirely within the NEC plan area and therefore was not tested as part of this study. Area 4B is located approximately 12 km south of Thornbury, in the vicinity of Ravenna, Red Wing and

Duncan (Figure 1 (back pocket)). Roughly two thirds of Area 4B lie within the NEC plan area. This area has not been tested for this study.

Area 4C is a large area of thin drift located south of Meaford and west of Thornbury (Figure 1 (back pocket) and 4). This area was tested with drill hole OGS-00-C1 (00DKA-053), which was cored through the entire Queenston Formation interval (Figure 30). The top approximately 34 m of the Queenston Formation in this hole averages 11.63 % CO₂, with individual sample values (n = 12) ranging from 5.19 to 15.60 % (data in Appendix 5). The remainder of the formation averages 15.77 % CO₂ (n=14). Medium- to coarse-grained bioclastic limestone interbeds occur between 42.69 and 45.29 m depth in OGS-00-C1 (or from about 40 to 42 m below the Queenston's upper contact). Towards the north and west this interval becomes thicker, as do the individual limestone interbeds.

Area 4D is a very large area that stretches from Cape Rich, northwest of Meaford to Owen Sound (Figures 1 (back pocket) and 4). It includes the area covered by Canadian Forces Training Area Meaford, but lies virtually all outside of the NEC plan area. This area was tested with drill hole OGS-00-C2 (00DKA-054), located on the Sydenham-St. Vincent Township Line approximately 6.5 km north of Highway 26 (Figure 1 (back pocket)). The top 20.33 m in this hole averages 12.34 % CO₂, whereas the lower 28.61 m averages 18.48 % CO₂. Significant medium- to coarse-grained limestone beds occur below 23.86 m depth in this hole. Although Area 4D is very large, only the top 20 to 30 m (extrapolating from OGS-00-C1) of the formation have low enough carbonate content to be considered a viable shale resource. Below this depth, significant limestone beds make the formation undesirable for quarrying. Targets in Area 4D should be in the vicinity of the Queenston Formation's upper contact with the Manitoulin Formation.

Area 4E extends from Owen Sound along the shore of Georgian Bay to the north and west to Colpoys Bay. Although not tested by a drill hole the stratigraphy and properties of the Queenston Formation here are likely similar to Area 4D. A large outcrop at Big Bay (00DKA-025) exposes the middle and lower part of the formation. It is capped by thick argillaceous bioclastic limestone beds. Again, targets for shale resources in this area should be as close as possible to the formation's upper contact with the Manitoulin Formation.

The Queenston Formation outcrop belt north of Area 4E was not examined for this study.

Conclusions and Recommendations

Two main geological criteria affecting the quality of shale from the Queenston Formation for use in brick manufacturing are carbonate content and presence of gypsum. Carbonate (primarily calcite) content occurs in 2 main forms: fine-grained detrital or cement carbonate in the shales and coarser grained interbeds (siltstones and sandstones) and as discrete fine- to coarse-grained limestone interbeds. The former is relatively abundant in the Queenston Formation, especially in the middle part of the formation. In fact, the main rock type of the formation could be called a calcareous, silty shale. This study has

systematically documented the previously reported northward increase in carbonate content of the shale component. Generally, there appears to be a gradation between mainly siliciclastic and mainly calcareous siltstones and fine-grained sandstones, however, details of this gradational relationship remain to be determined. Towards the northern part of its outcrop belt, medium- to coarse-grained bioclastic limestone beds occur in the middle of the formation and become more abundant and thicker toward the north and west.

Gypsum occurs as thin seams of white fibrous gypsum oriented sub-parallel to bedding and as nodules of various size, shape and colour. Gypsum in these various forms can occur almost anywhere in the Queenston Formation, but tends to be more prevalent in the middle part of the formation. They appear to occur in discrete horizons which can be traced, at a minimum, across a quarry property. Detailed studies should be undertaken to determine if these gypsiferous horizons can be correlated among quarries, drill holes and outcrops.

A strong relationship between CaO and CO₂ content indicates that calcite is the primary carbonate mineral and that CO₂ can be used as a proxy for carbonate content. Calcium (CaO) content, however, may be elevated locally due to the presence of gypsum. It is well documented that carbonate content is one of the main factors affecting brick colour for the Queenston Formation. Based on the analysis of the 6 presently active quarries and the reports of brick colour from respective producers, it was found that shale with a CO₂ content of up to 10 % yields red bricks and 10 to 15 % CO₂ yields yellow to buff coloured bricks. The only quarry producing yellow bricks is the Burlington Quarry, which stratigraphically is located in the middle of the Queenston Formation. None of the quarries had average CO₂ content that exceeded 15 %.

The largest areas of thin drift over the Queenston Formation are located in the Hamilton-Grimsby area of the Niagara Peninsula, the southern part of the Regional Municipalities of Halton and Peel and in the vicinity of Meaford and Owen Sound in Grey County.

From the point of view of carbonate content and thickness of shale deposits, the Niagara Peninsula contains the best potential resource. Issues limiting resource development there include distance to market (not evaluated in this report), urbanization (especially in the western part of the peninsula) and intensive, significant agricultural use (i.e., fruit orchards and vineyards). A large area of thin drift, mostly covered by farmland, occurs between Beamsville and Vineland. Only one small area of thin drift is located in the Peninsula east of Vineland.

The wide outcrop belt of Queenston Formation in Halton and Peel afford access to various stratigraphic levels within the formation and thus to shale with different properties that can yield different brick colours. The uppermost part of the formation, which represents the best part of the formation for the brick industry (because of low carbonate content and lack of gypsum), lies mainly within the NEC plan area and thus is not likely to be available for extraction. The Halton and Peel area is also host to large

areas of thin drift over the shale resource, however, most of these areas are also subject to rapid urban expansion.

Four areas of thin drift over the Queenston Formation, outside of the NEC plan area and current urban boundaries, have been identified by previous studies. These areas were tested by drilling in this or previous studies. Drill holes in 3 of these 4 areas encountered thicker drift than anticipated. It appears that these areas may be smaller or more irregularly shaped than originally mapped. It is recommended that detailed examination of available subsurface data (e.g., waterwell or other subsurface data) be conducted to verify the shape and extent of these thin drift areas, and if necessary, further drilling be done to confirm them.

In the north-central part of the study area, in Dufferin and Simcoe Counties, scattered areas of thin drift over the Queenston Formation occur outside of the NEC plan area. Although carbonate content is generally higher in this area, there are significant intervals, especially in the upper part (and possibly the lower part) of the formation, where average CO₂ content is approximately 10 %. One area, near Rosemont, may be underlain by the Georgian Bay Formation instead of the Queenston Formation.

There are large areas of thin drift cover over the Queenston Formation and outside of the NEC plan area in Grey County, in the northern part of the study area. In this area, the middle part of the formation contains significant medium- to coarse-grained limestone beds which limit resource quality and extractability. Also in this area, the upper part of the formation is more calcareous than equivalent strata to the south, however, average CO₂ content does not exceed 15 %. The upper part of the Queenston Formation in this area may be a good source of material for making yellow to buff coloured bricks. The lower part of the formation may also yield intervals with similar average carbonate content.

Recommendations for future investigations into the shale resources of the Queenston Formation should include:

- 1) more detailed investigation of drift thickness around previously identified thin drift areas (as mentioned above).
- 2) more detailed correlation among drill hole, quarry and outcrop sections, especially in the Halton and Peel regions where a relatively good data set exists.
- 3) additional data acquisition (e.g., field work and drilling) in the central and northern parts of the study area where data are sparse.
- 4) ceramic testing of all promising core intervals (especially from northern cores) to assess the colour and physical properties of fired shales.

Acknowledgments

The project could not have been accomplished without the assistance of the brick industry of Ontario, especially: Ray Martin, Iain Thompson and Nasiruddin Hirji (Canada Brick), Brad Duke and Claudio Sacilotto (Brampton Brick), and Joseph Alfano, Joseph Zamparo and Michael Rixner (Century Brick). Ken Steele (OGS-Toronto) provided important background information and on-going communicative links with the industry. Discussions with Tony Hamblin (GSC-Calgary), Paul Brogly and Peter Martini (University of Guelph) helped in understanding the sedimentology and stratigraphy of the Queenston Formation. Steve Holysh (Region of Halton) helped to elucidate the intricacies of drift thickness in the region. Technical assistance in the field and office were most capably provided by Andrew Wigston, Darren Villeneuve, Steve VanHaaften, Shannon Evers and Pascale Sergerie. The hard and expedient work of driller Charlie Pitre and drilling assistant Marc Hubbert (both of Lantech Drilling Services) was much appreciated.

References

- Armstrong, D.K. 1993. Paleozoic geology of the southern Bruce Peninsula area, southern Ontario; Ontario Geological Survey, Open File Report 5875, 19p.
- Armstrong, D.K. 2000. Shale resources of the Queenston Formation; *in* Summary of Field Work and Other Activities 2000, Ontario Geological Survey, Open File Report 6032, p.39-1 to 39-7.
- Armstrong, D.K. 2001. Geochemistry of Queenston Formation samples from outcrops, quarries and drill cores, southern Ontario; Ontario Geological Survey, Miscellaneous Release - Data 77.
- Armstrong, D.K and Goodman, W.R. 1990. Stratigraphy and depositional environments of Niagaran carbonates, Bruce Peninsula, Ontario, Field trip No. 4 guidebook; American Association of Petroleum Geologists, 1990 Eastern Section Meeting, hosted by the Ontario Petroleum Institute, London, Ontario, 59p.
- Baker, M.B. 1906. Clay and the clay industry of Ontario; Report of the Bureau of Mines, v.15, part 2, 127p.
- Bond, I.J. and Telford, P.G. 1976. Paleozoic geology of the Bolton area, southern Ontario; Ontario Division of Mines, Map 2338, scale 1:50,000.
- Bond, I.J., Liberty, B.A. and Telford, P.G. 1976. Paleozoic geology of the Brampton area, southern Ontario; Ontario Division of Mines, Map 2337, scale 1:50,000.

- Brady, J.G., Dean, R.S. 1966. Ceramic clays and shales of Ontario; Department of Energy, Mines and Resources, Mines Branch, Research Report R175, 125p.
- Brogly, P.J. 1984. The depositional environment of the Queenston Formation in southern Ontario; unpublished B.Sc. thesis, McMaster University, Hamilton, Ontario, 80p.
- Brogly, P.J. 1990. The depositional environments of the Queenston Formation (Upper Ordovician) in southern Ontario; unpublished M.Sc. thesis, University of Guelph, Guelph, Ontario, 173p.
- Brogly, P.J., Martini, I.P. and Middleton, G.V. 1998. The Queenston Formation: shale-dominated, mixed terrigenous-carbonate deposits of Upper Ordovician, semi-arid, muddy shores in Ontario, Canada; *Canadian Journal of Earth Sciences*, v.35, p.702-719.
- Caley, J.F. 1940. The Paleozoic geology of the Toronto-Hamilton area, Ontario. Geological Society of Canada, Memoir 224.
- Donaldson, W.S. 1989a. The depositional environment of the Queenston shale, southwestern Ontario; unpublished B.Sc. thesis, University of Western Ontario, London, Ontario, 106p.
- Donaldson, W.S. 1989b. The depositional environment of the Queenston shale, southwestern Ontario; *in* Proceedings, Ontario Petroleum Institute, 28th Annual Conference, London, Ontario, 27p.
- Dyer, W.S. 1925. The stratigraphy and paleontology of Toronto and vicinity. Part 6B: The stratigraphy and correlation of the Credit River section; Ontario Department of Mines, 32nd Annual Report, p. 117-134.
- Feenstra, B.H. 1972. Quaternary geology of the Niagara area, southern Ontario; Ontario Division of Mines, Preliminary Map P.764.
- Feenstra, B.H. in preparation. Quaternary geology of the Owen Sound area, southern Ontario; Ontario Geological Survey, Preliminary Map.
- Foerste, A. F. 1916. Upper Ordovician systems in Ontario and Quebec; Canada Department of Mines, Geological Survey, Memoir 83.
- Foerste, A.F. 1924. Upper Ordovician faunas of Ontario and Quebec; Geological Survey of Canada, Memoir 138, 255p.
- Golders Associates Ltd. and Rowell, D.J. 1996a. Aggregate resources inventory of the Regional Municipality of Halton, southern Ontario; Ontario Geological Survey, Aggregate Resources Inventory Paper 164, 74p.

Golders Associates Ltd. and Rowell, D.J. 1996b. Aggregate resources inventory of the Regional Municipality of Peel, southern Ontario; Ontario Geological Survey, Aggregate Resources Inventory Paper 165, 80p.

Grabau, A.W. 1908. A revised classification of the North American Silurian; Science (Washington D.C.), v. 27, p. 622-623.

Guillet, G.R. 1964. Clay and shale in Ontario, a review; Ontario Department of Mines, Preliminary Report 1964-2, 28p.

Guillet, G.R. 1967. The clay products industry of Ontario; Ontario Department of Mines, Industrial Mineral Report 22, 206p.

Guillet, G.R. 1977. Clay and shale deposits of Ontario; Ontario Geological Survey, Mineral Deposits Circular MDC 15, 117p.

Guillet, G.R. 1983. Mineral resources of south-central Ontario; Ontario Geological Survey, Open File Report 5431, 155p.

Guillet, G.R. and Joyce, I.H. 1987. The clay and shale industries of Ontario; Ontario Ministry of Natural Resources, 157p.

Hamblin, A.P. 1998. Upper Ordovician strata of the Ottawa Embayment: summary of literature; Geological Survey of Canada, Open File 3669, 6p.

Hamblin, A.P. 1999. Upper Ordovician strata of southwestern Ontario: synthesis of literature and concepts; Geological Survey of Canada, Open File 3729, 34p.

Johnson, M.D. 1983. Oil shale assessment project, deep drilling results 1982/83, Toronto region; Ontario Geological Survey, Open File Report 5477, 17p.

Johnson, M.D., Russell, D.J. and Telford, P.G. 1983. Oil shale assessment project, volume 2, drillholes for regional correlation 1981/82; Ontario Geological Survey, Open File Report 5459, 20p.

Johnson, M.D., Russell, D.J. and Telford, P.G. 1985. Oil shale assessment project, drillholes for regional correlation 1983/84; Ontario Geological Survey, Open File Report 5565, 49p.

Johnson, M.D., Armstrong, D.K., Sanford, B.V., Telford, P.G. and Rutka, M.A., 1992. Paleozoic and Mesozoic Geology of Ontario; in Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 2, p.907-1008.

Keele, J. 1924. Preliminary report on the clay and shale deposits in Ontario; Geological Survey of Canada, Memoir 142.

Kwong, K.P., Martini, I.P. and Narain, M. 1985. Ceramic properties of selected shale and clay resources in south central Ontario; Ontario Geological Survey, Open File Report 5571, 60p.

Liberty, B.A. 1969. Paleozoic geology of the Lake Simcoe area; Geological Survey of Canada, Memoir 355.

Liberty, B.A., and Bolton, T.E. 1971. Paleozoic geology of the Bruce Peninsula area, Ontario; Geological Survey of Canada, Memoir 360, 163p.

Liberty, B.A., Bond, I.J. and Telford P.G. 1976a. Paleozoic geology of the Hamilton area, southern Ontario; Ontario Division of Mines, Map 2336, scale 1:50,000.

Liberty, B.A., Bond, I.J. and Telford P.G. 1976b. Paleozoic geology of the Orangeville area, southern Ontario; Ontario Division of Mines, Map 2339, scale 1:50,000.

Liberty, B.A., Bond, I.J. and Telford P.G. 1976c. Paleozoic geology of the Dundalk area, southern Ontario; Ontario Division of Mines, Map 2340, scale 1:50,000.

Liberty, B.A., Feenstra, B.H. and Telford, P.G. 1976a. Paleozoic geology of the Grimsby area, southern Ontario; Ontario Division of Mines, Map 2343, scale 1:50,000.

Liberty, B.A., Feenstra, B.H. and Telford, P.G. 1976b. Paleozoic geology of the Niagara area, southern Ontario; Ontario Division of Mines, Map 2344, scale 1:50,000.

Martini, I.P. and Kwong, K.P. 1986. Geology and ceramic properties of selected shales and clays of southwestern Ontario; Ontario Geological Survey, Open File Report 5583, 116p.

McNaughton Hermsen Britton Clarkson Planning Limited, White Landscience, Robinson Consultants and Ontario Geological Survey 1998. Aggregate resources inventory of Dufferin County; Ontario Geological Survey, Aggregate Resources Inventory Paper 163, 65p.

Montgomery, R.J. 1930. The ceramic industry of Ontario; Ontario Department of Mines, Annual Report, v. 39, part 4, 196p.

Ontario Geological Survey 1982. Aggregate resources inventory of the City of Burlington, Regional Municipality of Halton; Ontario Geological Survey, Aggregate Resources Inventory Paper 45, 31 p.

Ontario Geological Survey 1984a. Aggregate resources inventory of Adjala Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 2, 29 p.

Ontario Geological Survey 1984b. Aggregate resources inventory of Osprey Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 86, 32 p.

Ontario Geological Survey 1985a. Aggregate resources inventory of the Regional Municipality of Hamilton-Wentworth; Ontario Geological Survey, Aggregate Resources Inventory Paper 50, 53 p.

Ontario Geological Survey 1985b. Aggregate resources inventory of the towns of Grimsby and Lincoln and the Township of West Lincoln, Regional Municipality of Niagara; Ontario Geological Survey, Aggregate Resources Inventory Paper 104, 31 p.

Ontario Geological Survey 1985c. Aggregate resources inventory of Derby Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 112, 37 p.

Ontario Geological Survey 1985d. Aggregate resources inventory of Sydenham Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 118, 32 p.

Ontario Geological Survey 1985e. Aggregate resources inventory of Keppel and Sarawak Townships; Ontario Geological Survey, Aggregate Resources Inventory Paper 119, 39 p.

Ontario Geological Survey 1991a. Aggregate resources inventory of Collingwood Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 87, 50 p.

Ontario Geological Survey 1991b. Bedrock geology of Ontario, southern sheet; Ontario Geological Survey, Map 2544, scale 1:1 000 000.

Ontario Geological Survey 1992a. Aggregate resources inventory of Euphrasia Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 99, 47 p.

Ontario Geological Survey 1992b. Aggregate resources inventory of St. Vincent Township; Ontario Geological Survey, Aggregate Resources Inventory Paper 131, 37 p.

Parks, W.A. 1925. The stratigraphy and paleontology of Toronto and vicinity; part 6A: Stratigraphy and correlation of the Dundas Formation; Ontario Department of Mines, Annual Report, v. 22, part 7, p. 89-116.

Proctor and Redfern Limited 1978. The clay brick industry and the shale resources of Ontario; A report to the Clay Brick Association of Canada, 18p.

Rudkin, D., Stott, C., Tetreault, D. and Rancourt C. 1998. Ordovician and Silurian rocks and fossils of the southern Georgian Bay area, Ontario; Eighth Canadian Paleontology Conference, Field Trip Guidebook, Collingwood.

Rutka, M.A. and Vos, M.A. 1993. The clay products industry and shale resources in southern Ontario; Ontario Geological Survey, Open File Report 5842, 66p.

Sanford, B.V. 1961. Subsurface stratigraphy of Ordovician rocks in Southwestern Ontario. Geological Survey of Canada, Paper 60-26, 54p.

Steele, K.G. 2001. Report of Activities 2000, Resident Geologist Program, Southern Ontario Regional Resident Geologist (Southwestern Ontario District); Ontario Geological Survey, Open File Report 6052, 29p.

Tarrant, G.A. (1977). Taxonomy, biostratigraphy and paleoecology of Late Ordovician conodonts from southern Ontario; unpublished M.Sc. thesis, University of Waterloo, Waterloo, Ontario, 240p.

Telford, P.G. 1976a. Paleozoic geology of the Collingwood-Nottawasaga area, southern Ontario; Ontario Division of Mines, Map 2341, scale 1:50,000.

Telford, P.G., 1976b. Paleozoic geology of the Guelph area, southern Ontario; Ontario Division of Mines, Map 2342, scale 1:50,000.

Telford, P.G. and Narain, M. 1980. Industrial mineral resources inventory of the Niagara Escarpment Planning Area; Ontario Geological Survey, Open File Report 5313, 310p.

Vos, M.A. 1975. Potential clay and shale resources of central Ontario; Ontario Geological Survey, Open File Report, 47p.

Williams, D.A. and Telford, P.G. 1986. Paleozoic geology of the Ottawa area; Geological Association of Canada, Annual Meeting, Ottawa, Ontario, Field Trip Guidebook No. 8, 25p.

APPENDIX 1

Mapping station information (modified after Armstrong 2001).

Appendix 1: Mapping station information (UTM coordinates in NAD-83 datum; station type codes: d = drill hole, q = quarry, o = natural outcrop, x = excavation or roadcut).

Station #	Location Name	UTM east	UTM north	NTS map #	Station Type	Queenston Fm section thickness (m)	# of lithologic units	Station Description	Station Datum
00DKA-001	Milton drill core: OGS-83-01	583798	4821216	30 M/12	d	149.44	not det	OGS core stored at WGMC; log published in OFR 5477.	ground surface, floor of Dufferin Aggregates quarry.
00DKA-002	Burlington Quarry (Canada Brick)	596915	4807823	30 M/05	q	18.20	8	section measured and sampled in NE corner of quarry	green bed equivalent to quarry floor in southeast corner
00DKA-003	Cheltenham Quarry (Brampton Brick)	585940	4843531	30 M/12	q	22.95	6	measured and sampled sump section, drainage ditch and south face of quarry	water level in sump, south side of quarry
00DKA-004	Milton Quarry (Canada Brick)	587641	4817641	30 M/12	q	28.00	9	measured and sampled SW and NW quarry walls	quarry floor
00DKA-005	Mount Pleasant subdivision	594884	4837340	30 M/12	x	4.15	3	excavation for buried services in new subdivision	base of excavation
00DKA-006	A.C. Martin Quarry (Century Brick)	584152	4834600	30 M/12	q	10.50	3	measured and sampled SW wall of quarry	quarry floor
00DKA-007	Streetsville Quarry (Canada Brick)	602244	4826246	30 M/05	q	18.20	12	measured and sampled sections in sump, in drainage ditch, and along south wall near SW corner.	water level in sump, southeast corner of quarry
00DKA-008	Cheltenham badlands	584881	4847130	30 M/12	o	24.00	5	measured and sampled series of gullies to form composite section, on east side of road.	base of outcrop

Appendix 1: Mapping station information (UTM coordinates in NAD-83 datum; station type codes: d = drill hole, q = quarry, o = natural outcrop, x = excavation or roadcut).

Station #	Location Name	UTM east	UTM north	NTS map #	Station Type	Queenston Fm section thickness (m)	# of lithologic units	Station Description	Station Datum
00DKA-009	East of Norval, on creek north of Credit River	592997	4833485	30 M/12	o	3.50	2	outcrop is on west side of tributary and is inaccessible due to high water	creek water level
00DKA-010	Georgetown - Credit River, across from old mill	588273	4834744	30 M/12	o	5.15	1	large slope on north side of river west of Maple (?) Street bridge	river water level
00DKA-011	Georgetown - Credit River, northwest of ruins	589133	4834396	30 M/12	o	6.00	1	section is long and continues west around bend for 10's of metres	river water level
00DKA-012	Credit River valley, west of Huttonville	595495	4833446	30 M/05	o	1.70	1	scattered outcrops along tributary creek on north side of Credit River	creek water level
00DKA-013	Credit River, 1km west of Huttonville	595280	4833111	30 M/05	o	3.75	3	on point in Credit River, 1 km west of Huttonville, west of station 00DKA-012	river water level
00DKA-014	Aldershot Brickplant - west site (Canada Brick)	592819	4797840	30 M/05	q	22.00	8	large excavated face behind new brick plant	asphalt pavement behind brick plant
00DKA-015	Aldershot west site, north end (Canada Brick)	592518	4798194	30 M/05	o	0.55	1	ditch and trail/road outcrop	base of outcrop
00DKA-016	Aldershot west site, north end, southwest of 00DKA-015 (Canada Brick)	592519	4798166	30 M/05	o	1.00	1	ditch and trail/road outcrop	base of outcrop
00DKA-017	Aldershot west site - ravine trail section (Canada Brick)	592596	4798012	30 M/05	o	17.50	2	trail up side of ravine	base of outcrop
00DKA-018	Aldershot east site - ravine at north end (Canada Brick)	592921	4799101	30 M/05	o	12.50	2	exposure on side of ravine	base of outcrop

Appendix 1: Mapping station information (UTM coordinates in NAD-83 datum; station type codes: d = drill hole, q = quarry, o = natural outcrop, x = excavation or roadcut).

Station #	Location Name	UTM east	UTM north	NTS map #	Station Type	Queenston Fm section thickness (m)	# of lithologic units	Station Description	Station Datum
00DKA-019	Bayview Quarry - south of Meaford	532925	4932869	41 A/10	x	0.50	2	sampled 10 - 20 cm of Queenston Formation in floor/sump of quarry, beneath Manitoulin Formation	base of drainage ditch in quarry
00DKA-020	Irish Mountain lookout - west of Meaford	526673	4943165	41 A/10	x	5.65	3	roadcut on road into Meaford Tank Range	base of roadcut
00DKA-021	Inglis Falls roadcut - Owen Sound	50501	4930530	41 A/10	x	1.50	1	sample of Cabot Head Fm approx. 40 cm below contact with Fossil Hill Fm	base of roadcut
00DKA-022	Dodd's Hill, Big Bay Road - north of Owen Sound	504000	4956880	41 A/15	x	6.45	2	Fossil Hill overlying Cabot Head Fm - sample of Cabot Head Fm	base of roadcut
00DKA-023	Lion's Head beach	480086	4982452	41 H/03	o	0.60	1	Fossil Hill overlying Wingfield Fm - sample of Wingfield Fm	base of outcrop
00DKA-024	Rush Cove - southeast of Lion's Head	487400	4978123	41 A/14	x	1.60	1	Dyer Bay overlying Cabot Head Fm - sample of Cabot Head Fm	base of roadcut
00DKA-025	Big Bay roadcut - east of Wiarton	505917	4960352	41 A/15	x	17.80	8	~ 10 yr. old excavation; all Queenston Fm; limestone at top.	base of roadcut
00DKA-026	Owen Sound east	505684	4937068	41 A/10	o	15.15	1	outcrop on side of hill, on east side of Owen Sound; Queenston Fm overlain by Manitoulin Fm	base of outcrop
00DKA-027	7 Sideroad, south of Meaford	533133	4933598	41 A/10	x	21.15	1	series of low rolling roadcuts, on south side of 7th Sideroad	base of roadcut
00DKA-028	Grey County Road 7 - south of Meaford	533315	4936364	41 A/10	x	0.30	1	scree covered ditch outcrop top of hill south of Meaford, on east side of Grey Road 7	base of roadcut

Appendix 1: Mapping station information (UTM coordinates in NAD-83 datum; station type codes: d = drill hole, q = quarry, o = natural outcrop, x = excavation or roadcut).

Station #	Location Name	UTM east	UTM north	NTS map #	Station Type	Queenston Fm section thickness (m)	# of lithologic units	Station Description	Station Datum
00DKA-029	Ten Hill - north of Creemore	568293	4910013	41 A/08	x	0.20	1	poor clayey outcrop in ditch	base of roadcut
00DKA-030	Road south of Creemore	570074	4905824	41 A/08	x	2.70	1	small road cut/outcrop on hill south of Creemore	base of roadcut
00DKA-031	Mulmur Twp., west of Mansfield	569821	4892334	41 A/01	x	7.75	1	series of roadcut outcrop's up hill on side of valley - below site of OGS-00-B1	base of roadcut
00DKA-032	Hockley Valley, Road 7	574251	4868111	40 P/16	x	11.50	5	large roadcut on north side of Road #7	base of roadcut
00DKA-033	Bronte Creek, s. of QEW, w. of Bronte Rd	602072	4806884	30 M/05	o	1.70	1	below Quality Inn Hotel, on southeast side of Bronte Creek	river water level
00DKA-034	Sixteen Mile Creek, Lion's Valley Park, north of Dundas St.	600698	4812824	30 M/05	o	5.40	3	long outcrop along east side of river, north of park	river water level
00DKA-035	tributary on east of Sixteen Mile Creek, Lion's Valley Park	600927	4812811	30 M/05	o	0.80	1	pop-up in creek bed; tributary flowing in from east, in floor of valley	river water level
00DKA-036	Bronte Creek, northwest of Zimmerman, north of No.2 Sideroad	593469	4808936	30 M/05	o	3.45	4	river cut on east side	river water level
00DKA-037	Bronte Creek, north of QEW, west of Bronte Rd	601812	4807071	30 M/05	o	5.80	5	north of station 00DKA-033, on east side of Bronte Creek	river water level
00DKA-038	Sixteen Mile Creek, under HWY 407	598372	4813355	30 M/05	o	20.85	4	~1 m high outcrop on both sides of creek and large cliff section on west side	river water level
00DKA-039	Bronte Creek at HWY 407	595874	4808037	30 M/05	o	~10	1	long outcrop on SW side, not sampled	river water level
00DKA-040	Sixteen Mile Creek at HWY 407 - access road	598428	4813183	30 M/05	x	14.15	6	access road down to west side of Sixteen Mile Creek	base of roadcut

Appendix 1: Mapping station information (UTM coordinates in NAD-83 datum; station type codes: d = drill hole, q = quarry, o = natural outcrop, x = excavation or roadcut).

Station #	Location Name	UTM east	UTM north	NTS map #	Station Type	Queenston Fm section thickness (m)	# of lithologic units	Station Description	Station Datum
00DKA-041	Grindstone Creek and Falls, at Waterdown	590102	4798111	30 M/05	o	10.50	3	outcrop on west side	base of outcrop
00DKA-042	Devil's Punchbowl, Stoney Creek	600902	4785071	30 M/04	o	16.80	2	large outcrop on east side	base of outcrop
00DKA-043	Ontario Power Generation core #NF-33 - at Niagara Falls	657346	4777945	30 M/03	d	139.63	not det	only examined from base of Whirlpool Fm down - core did not intersect whole thickness of Queenston Fm	ground surface
00DKA-044	Ontario Power Generation tunnel excavation stockpile - Niagara Falls	658257	4778264	30 M/03	x	130.00	1	stockpile at Power Generation Station, south side of reservoir	none
00DKA-045	drillhole OGS-00-A1	597916	4811095	30 M/05	d	31.55	20	Hwy 407 and Bronte Rd. (Hwy 25)	ground surface
00DKA-046	drillhole OGS-00-A2	600367	4814323	30 M/05	d	31.06	24	east of Oakville Landfill	ground surface
00DKA-047	drillhole OGS-00-A4	596096	4815637	30 M/05	d	31.32	22	4th Line South of Britannia Rd., SE of Milton	ground surface
00DKA-048	drillhole OGS-00-A6	592246	4829873	30 M/12	d	23.70	15	Communication Tower access road, off of Mountainview Road, south of Georgetown	ground surface
00DKA-049	drillhole OGS-00-A8	587059	4826268	30 M/12	d	23.31	10	10th Line Road, southwest of Georgetown	ground surface
00DKA-050	drillhole OGS-00-A10	591779	4837118	30 M/12	d	11.04	5	Wanless Road, north of Norval	ground surface
00DKA-051	drillhole OGS-00-B1	569861	4892115	41 A/01	d	46.99	25	15th Side Road and 1st Line East, Mulmur Twp.	ground surface
00DKA-052	drillhole OGS-00-B4	569122	4912183	41 A/08	d	20.12	11	15/16 Side Road, Clearview Township, Ten Hill, north of Creemore	ground surface
00DKA-053	drillhole OGS-00-C1	532847	4932652	41 A/10	d	75.13	not det	Bayview Quarry, south of Meaford	ground surface

Appendix 1: Mapping station information (UTM coordinates in NAD-83 datum; station type codes: d = drill hole, q = quarry, o = natural outcrop, x = excavation or roadcut).

Station #	Location Name	UTM east	UTM north	NTS map #	Station Type	Queenston Fm section thickness (m)	# of lithologic units	Station Description	Station Datum
00DKA-054	drillhole OGS-00-C2	520908	4944428	41 A/10	d	48.94	43	St. Vincent-Sydenham Road, northeast of Owen Sound	ground surface

APPENDIX 2

Composite sample information (modified after Armstrong 2001).

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- log	# Unit
	From	To				
00DKA102a	-1.05	0.00	Burlington Quarry	dark red shale, with (~25%) green shale and siltstone; most green beds < 5 cm thick; top marked by 25 cm thick green bed.		1
00DKA102b	0.00	2.25	Burlington Quarry	dark brown-red shale, with brown-red and green (minor) siltstone hard beds.		2
00DKA102c	2.25	2.85	Burlington Quarry	red shale and siltstone, with 3 - 4 green siltstone beds; green beds < 10 cm thick; contains gypsum nodules (to south in main pit); horizontal gypsum fracture at top.		3
00DKA102d	2.85	5.30	Burlington Quarry	red shale and siltstone, with minor green siltstone beds and light red-grey fine-grained limestone beds; capped by laterally persistent green bed; gypsum nodules up to 3.7 m level in main pit area.		4
00DKA102e	5.30	9.05	Burlington Quarry	two cycles consisting of ~70 cm red shale overlain by 1.10 - 1.25 m intervals of interbedded red or green siltstones and red shales; top bed called "upper datum" in notes; siltstones are commonly laminated and have rippled tops.		5
00DKA102f	9.05	13.30	Burlington Quarry	red shale with thin regularly spaced red and green siltstone beds; interval @ 10.75 - 11.85 m contains more hard beds; unit capped by 2 green hard beds.		6
00DKA102g	13.30	15.45	Burlington Quarry	red shale with interbeds of red siltstone and minor green siltstone; finer grained in basal 1.1 m; still >50% muddy silt in upper part; capped by 10 - 15 cm grey-green siltstone/limestone.		7
00DKA103a	-0.60	0.00	Cheltenham Quarry	green and dark red siltstone; laterally discontinuous beds; unit capped by 10 cm green bed.		1
00DKA103b	0.00	2.40	Cheltenham Quarry	red mudstone with 20 % red and green siltstone beds in top 95 cm; sample only up to 2.40 m in ramp wall/ sump; rest of unit, up to 3.00 m, exposed in drainage ditch. (unit 3, @ 3.00 to 3.95 m, is covered and was not sampled)		2
00DKA103c	3.95	6.55	Cheltenham Quarry	red mudstone with some green mottles and laterally discontinuous green beds up to 25 cm thick, and small gypsum nodules; capped by two green beds up to 25 cm thick and with small scale cross-lamination.		4
00DKA103d	6.55	16.85	Cheltenham Quarry	mostly red mudstone, with minor thin to thick green mudstone beds; scattered small green mottles; unit capped by laterally persistent thin green hard bed.		5
00DKA103e	16.85	22.35	Cheltenham Quarry	mostly red mudstone, with minor thin to thick green mudstone beds; scattered small green mottles; top 1.4 m is weathered.		6
00DKA104a	0.00	4.95	Milton Quarry	mostly dark red, massive shale; few green beds and large mottles; note: unit 1 (-0.2 - 0 m) sampled as single bed (00DKA004a)		2
00DKA104b	4.95	5.50	Milton Quarry	mostly green shale and siltstone; "triple" of green hard beds; 25 cm thick basal bed.		3

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA104c	5.50	7.10	Milton Quarry	mostly dark red, massive, shale, with thin (< 5 cm) green shale beds, local green mottles, unit capped by "doublet" of green shale beds.	4
00DKA104d	7.10	9.00	Milton Quarry	mostly dark red, massive shale; capped by thin to medium green bed.	5
00DKA104e	9.00	12.70	Milton Quarry	mostly dark red, massive shale, with thin, discontinuous green beds; capped by medium green bed.	6
00DKA104f	12.70	16.40	Milton Quarry	dark red, massive shale (100%) in basal 2.5 m, overlain by 1.2 m of interbedded red (80%) shale and green (20%) beds; unit capped by green bed.	7
00DKA104g	16.40	20.70	Milton Quarry	mostly dark red shale, with thin (< 10 cm) discontinuous green beds (< 10%); more green beds in upper 80 cm; capped by green bed; small calcite lined vugs @ 17.30 m.	8
00DKA104h	20.70	24.00	Milton Quarry	mostly dark red-brown shale, with few small to medium green mottles; capped with thin (~ 5 cm) green bed.	9
00DKA104i	24.00	25.50	Milton Quarry	weathered red shale, with sparse thin green beds; sampled only up to 25.50 m; top of quarry is 2.5 m higher.	10
00DKA105a	0.00	1.75	Mount Pleasant	mostly medium- to thin-parted beds of massive brown-red silty shale, with thin (< 5cm) discontinuous green shale beds and small to medium green mottles.	1
00DKA105b	1.75	2.75	Mount Pleasant	interbedded brown-red, shale (40%), green shale (40%) and green-grey limestone (20%); limestone is very fine-grained and occurs in 3 to 7 cm thick tabular beds; top 0.5 m of unit is weathered (especially green beds).	2
00DKA105c	2.75	4.15	Mount Pleasant	red shale with minor green beds in basal 0.7 m; possible green shale bed at top; large scale concave-up lensoidal parting.	3
00DKA106a	0.50	2.25	A.C. Martin Quarry	red shale with 2 green shale/siltstone intervals (at 1.5 - 1.60 m and 2.15 - 2.25 m) with 2 to 3 thin beds each and associated large green mottles up to 50 cm thick; individual green beds grade laterally into red; large green mottles are locally enlarged along sub-vertical fractures; bottom 0.50 m covered (unit 1 starts at 0 m = quarry floor).	1
00DKA106b	2.25	5.25	A.C. Martin Quarry	red shale with thin, discontinuous green beds and medium to large green mottles.	2

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- logic
	From	To			
00DKA106c	5.25	10.50	A.C. Martin Quarry	red shale with sparse discontinuous green beds and mottles; unit extends up to 11 m, but top 0.50 m is covered; topmost 0.75 m of sample is weathered - possibly contaminated with overburden.	3
00DKA107a	0.00	1.30	Streetsville Quarry	laminated red siltstone (50%) thinly interbedded with red (45%) and green (5%) shales; section at pumphouse/sump; N.B. unit 1 is Georgian Bay Fm and is located in sump, so no composite sample taken.	2
00DKA107b	1.30	2.30	Streetsville Quarry	red shale (90%), with thin (2 - 5 cm) green shale (5%), and red and green siltstone (5%) interbeds; less shale to top(?).	3
00DKA107c	2.30	3.40	Streetsville Quarry	interbedded grey limestone and red and green shale; tabular 20 cm bed(s) at base, locally shalier to top (i.e. pumphouse).	4
00DKA107d	3.40	4.85	Streetsville Quarry	red shale with green shale band in middle and a few thin (< 15 cm) green argillaceous limestone beds	5
00DKA107e	4.85	5.15	Streetsville Quarry	thick limestone bed, with sharp base, and green shale	6
00DKA107f	5.15	6.75	Streetsville Quarry	red shale and siltstone (90%) with thin green shale and siltstone beds (5%) and dark grey limestone beds (< 5%); quarry floor is at approx. 5.75 m.	7
00DKA107g	6.75	7.90	Streetsville Quarry	red (75%) shale and green siltstone/limestone (25%) interbeds; basal bed is green argillaceous limestone.	8
00DKA107h	7.90	10.05	Streetsville Quarry	lower 1/2 is interbedded red (70) shale and green (30) siltstone/limestone beds; top 1/2 is red shale with minor discontinuous green beds; basal bed is limestone; limestone also at 8.60 - 8.65 m.	9
00DKA107i	10.05	12.25	Streetsville Quarry	interbedded red (64%) shale and green shale/siltstone/limestone (36%); sparse green beds in upper 0.75 m; tabular, green-grey argillaceous limestone bed at top.	10
00DKA107j	12.25	14.10	Streetsville Quarry	interbedded red shale (90%) and green shale/siltstone/limestone (10%); top 70 cm is mostly red shale; basal 1.15 m interbedded interval is bounded by thin green argillaceous limestone beds; shale beds are thicker parted (up to 25 cm) and harder than elsewhere; sample very muddy and possibly contaminated by overburden.	11
00DKA107k	14.10	18.20	Streetsville Quarry	14.10 - 15.45 m: interbedded red (75%) and green (25%) with evenly spaced (10 - 20 cm) green beds; 15.45 - 18.20 m: red blocky shale with minor (< 10 %) green beds; possibly new cycle starting at 17.65 m.	12

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- logic Unit #
	From	To			
00DKA111a	0.05	0.50	Georgetown - Credit River, NW of ruins	red shale with minor green shale and siltstone; unit 1, grey-green argillaceous limestone bed at 0 - 0.05 m is bed sample 00DKA011a.	2
00DKA111b	0.60	1.60	Georgetown - Credit River, NW of ruins	interbedded red shale and laterally discontinuous green/grey-green siltstone/limestone beds; capped by 5 cm limestone bed with low angle lamination; unit 3, green-grey limestone bed at 0.5 to 0.6 m is bed sample 00DKA011b	4
00DKA111c	1.60	1.90	Georgetown - Credit River, NW of ruins	red shale	5
00DKA111d	1.90	3.00	Georgetown - Credit River, NW of ruins	interbedded red shale and grey-green argillaceous limestone/siltstone hard beds.	6
00DKA113a	0.00	1.25	Credit River, 1km west Huttonville	interbedded red shale and thin- to medium-bedded green shale and argillaceous limestone hard beds (~10%); shales 10 - 50 cm thick; hard beds < 5 - 10 cm, vary laterally; hard beds commonly laminated; unit 1 muddier than other units.	1
00DKA113b	1.25	1.95	Credit River, 1km west Huttonville	interbedded red shale and thin- to medium-bedded green shale and argillaceous limestone hard beds (~20%); shales 10 - 50 cm thick; hard beds < 5 - 10 cm, vary laterally; hard beds commonly laminated; 2 limestone beds at base; unit 2 extends up to 2.25 m, but top 30 cm not sampled; unit 3, at 2.25 - 3.76 m, similar to unit 1(?), not sampled.	2
00DKA114a	-1.25	0.40	Aldershot Brickplant	red shale (75%) with green shale and limestone interbeds; limestone beds commonly core green shale beds and are cross-laminated; small gypsum nodules locally abundant toward top of unit; unit capped by 5 cm green argillaceous limestone bed with horizontal and ripple cross-laminations; 0 m elevation is top of asphalt behind plant.	1
00DKA114b	0.40	3.20	Aldershot Brickplant	mostly red shale, with minor thin green shale and siltstone beds, locally abundant small gypsum nodules (especially in lower 2/3), and thin (< 3 mm) sub-horizontal gypsum-filled fractures between 1.2 m and 2.2 m; thin (< 20 cm) lens of light green, ripple cross-laminated, siltstone/sandstone, < 10 m wide at ~ 1.60 m.	2

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- logic Unit #
	From	To			
00DKA114c	3.20	5.30	Aldershot Brickplant	interbedded red shale (80%) and green shale/siltstone; red intervals up to 1 m thick; green beds range from < 5 to 10 cm thick, are commonly laminated and/or ripple cross-laminated, have coarser grained; green beds more abundant toward top of unit (above 4.8 m).	3
00DKA114d	5.30	8.30	Aldershot Brickplant	mostly red shale, with laterally discontinuous, < 10 cm thick, green beds (<10%); small gypsum nodules throughout (less abundant than units 1 and 2); gypsum-filled fractures @ 5.9 m and 6.6 m; top contact taken at base of green shale under light green siltstone.	4
00DKA114e	8.30	10.15	Aldershot Brickplant	red shale with thin to thick green (~25%) shale and siltstone interbeds; up to 0.45 cm thick green interval at base, overlain by up to 1.4 m mostly red interval, and capped by interbedded interval (60% red, 40% green); green siltstones commonly contain ripple cross-lamination; small gypsum nodules locally abundant (especially in middle red interval).	5
00DKA114f	10.15	12.45	Aldershot Brickplant	mostly red shale, with minor thin green siltstone and shale beds (especially in middle of unit); some small gypsum nodules near base of unit (basal 0.5 m).	6
00DKA114g	12.45	16.85	Aldershot Brickplant	red shale with green siltstone and shale interbeds (< 20%); capped by thin green bed; unit is at top of east side of section; unit 8 extends up to 22.20 m on west side of section, but was not accessible for composite sample.	7
00DKA125a	1.15	2.30	Big Bay roadcut	red and green shale, with minor red, very fine-grained, argillaceous sandstone beds.	2
00DKA125b	4.00	8.20	Big Bay roadcut	red shale with green shale (<20%), very fine-grained and siltstone (<5%); two horizons with large orange gypsum nodules; also fibrous gypsum-filled sub-horizontal fractures; all rock types are calcareous.	4
00DKA125c	8.20	9.60	Big Bay roadcut	red shale with green shale; similar to unit 4, but with a few thin (< 5cm) grey-green argillaceous calcisiltites/limestones; limestone beds have planar bases, small burrow traces and shaly tops; sub-horizontal gypsum fracture.	5
00DKA125d	9.60	11.45	Big Bay roadcut	green and light red shale and thin limestone interbeds; limestone beds typically < 2 cm thick and more abundant towards the top; limestone beds in top 0.5 m contain abundant small burrows.	6

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- logic Unit #
	From	To			
00DKA134a	0.00	1.80	Sixteen Mile Ck, Lion's Valley Pk	red shale (90%) with green hard beds; base of unit at water level; green beds typically < 5 cm, some up to 10 cm thick; green beds are calcareous; red shale is; green beds are generally continuous, although vary in thickness laterally; some green beds are lenticular (channels?) 2 - 3 m wide.	1
00DKA134b	1.80	4.80	Sixteen Mile Ck, Lion's Valley Pk	interbedded red (up to 90%) shale and green shale and siltstone; green beds up to 15 cm thick and laterally discontinuous; basal green bed is 20 cm thick.	2
00DKA136a	0.00	0.40	Bronte Ck, NW of Zimmerman	red flaky shale with thin green argillaceous limestone/siltstone beds (<5%).	1
00DKA136b	0.40	1.15	Bronte Ck, NW of Zimmerman	interbedded red and green shale (50%) and green and red hard beds (siltstone/limestone and siltstone); red shale beds up to 7 cm thick; hard beds up to 10 cm thick; unit capped by 10 cm of green shale.	2
00DKA136c	1.15	2.55	Bronte Ck, NW of Zimmerman	red shale (90%) with a few thin hard beds.	3
00DKA136d	2.55	3.10	Bronte Ck, NW of Zimmerman	interbedded red and green shale (50%) and green and red hard beds; similar to unit 2.	4
00DKA137a	0.50	1.40	Bronte Creek, n. of QEW, w. of Bronte Rd	mostly red, shale with a few green or red hard beds; a few thin green beds in basal 20 cm; 2 green and red hard beds, up to 13 cm thick, in top 40 cm; uppermost hard bed caps unit and is ripple cross-stratified.	2
00DKA137b	1.40	2.15	Bronte Creek, n. of QEW, w. of Bronte Rd	red shale with discontinuous red hard beds in the middle, and minor thin green shale at top; red hard beds are ripple cross-laminated and contain rip-up clasts.	3
00DKA137c	2.15	2.80	Bronte Creek, n. of QEW, w. of Bronte Rd	interbedded red and green hard beds (60%) and red shale; hard beds are laterally discontinuous, cross-laminated, up to 10 cm thick; red shale intervals are up to 15 cm thick.	4
00DKA138a	4.15	4.90	Sixteen Mile Creek under HWY 407	red shale with thin discontinuous green argillaceous limestone and siltstone beds (<25%); green beds are horizontally laminated.	1
00DKA138b	4.90	7.85	Sixteen Mile Creek under HWY 407	interbedded red shale and green hard beds; shale content varies from 30% in lower 1/3, to 60% in middle 1/3, to 40% in upper 1/3; hard beds vary from 10 - 12 cm thick, tabular beds with rip-ups and low angle lamination, to thin (< 5 cm), tabular to slightly irregular beds; thinner beds are more abundant, and more discontinuous; good thick tabular beds at base and top of unit.	2

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA140a	0.00	4.45	Sixteen Mile Creek at HWY 407 - access road	red shale with minor green shale beds and a few green to light red siltstone hard beds; some small to medium green mottles; appears to consist of two coarsening upwards cycles capped by green siltstone beds.	1
00DKA140b	4.45	6.60	Sixteen Mile Creek at HWY 407 - access road	red shale with green beds becoming more abundant towards top; green hard beds typically tabular with sharp bases and gradational tops; <10% green shale in lower 2/3; ~25% green hard beds and shale in top 1/3; thin sub-horizontal gypsum-filled fractures up to 6.05 m; large gypsum nodule at 5.90 m; small red nodules (gypsum?) at 6.10 - 6.20 m.	2
00DKA140c	6.60	8.10	Sixteen Mile Creek at HWY 407 - access road	similar to unit 2; red shale dominated basal 1 m; up to 25% green and red hard beds in top 0.9 m; hard beds have faint horizontal to low angle lamination; 8.10 to 8.50 m not sampled (bag missing).	3
00DKA140d	8.50	10.55	Sixteen Mile Creek at HWY 407 - access road	mostly red shale (~50%) with thin red hard beds (~40%) and some thick green hard beds (~10%) towards the top; red and green hard beds up to 15 cm thick.	4
00DKA140e	10.55	11.50	Sixteen Mile Creek at HWY 407 - access road	similar to unit 4; hard red beds and light red-green mottled hard beds with red shale; basal 40 cm is shallower; some red hard beds are faintly laminated; topmost bed is very hard light red-green limestone (caps "solid" bedrock).	5
00DKA144a	n/a	n/a	Ontario Power Generation - stockpile	OPG stockpile, west side.	1
00DKA144b	n/a	n/a	Ontario Power Generation - stockpile	OPG stockpile, northeast side.	1
00DKA145a	4.65	5.20	drill hole OGS-00-A1	weathered, interbedded red and green (60%) shale.	1
00DKA145b	5.20	6.62	drill hole OGS-00-A1	mostly massive red shale (13% coarse/green beds).	2
00DKA145c	6.62	7.45	drill hole OGS-00-A1	interbedded red shale and intraclastic conglomerate, and green and light green shale and siltstone (70 % coarse/green beds).	3
00DKA145d	7.45	9.10	drill hole OGS-00-A1	mostly red shale with local round intraclasts (22% coarse/green beds).	4
00DKA145e	9.10	11.65	drill hole OGS-00-A1	interbedded light green and light red siltstone, and red shale, with some red pebble lags (35% coarse/green beds).	5
00DKA145f	11.65	13.64	drill hole OGS-00-A1	mostly red shale, with some light green and light red siltstone beds (15% coarse/green beds).	6
00DKA145g	13.64	14.97	drill hole OGS-00-A1	interbedded red shale (with red pebbles), light green shale and siltstone, and light red siltstone (40 % coarse/green beds).	7

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# - litho
	From	To			
00DKA145h	14.97	17.41	drill hole OGS-00-A1	red shale (some with round red pebbles/intraclasts) with varying amounts of interbedded light green siltstone and shale and light red siltstone (range from 15 to 35 % coarse/green beds); small red gypsum nodule @ 17.03 m.	8, 9, 10
00DKA145i	17.41	20.00	drill hole OGS-00-A1	interbedded red shale and pebble light red and light green siltstone, and green shale (55% coarse/green beds); sparse small red gypsum nodules 2 gypsum seams near base.	11
00DKA145j	20.00	22.79	drill hole OGS-00-A1	mostly dark red shale, with thin, evenly spaced light red and light green siltstone beds (19% coarse/green beds); 1 thin gypsum seam.	12
00DKA145k	22.79	24.08	drill hole OGS-00-A1	interbedded red and green siltstone, shale, and mud pebble/chip conglomerate (44% coarse/green beds); 1 thin gypsum seam.	13
00DKA145l	24.08	26.11	drill hole OGS-00-A1	red shale with thin (< 5cm) light green siltstone interbeds and minor intraclastic beds (10% coarse/green beds).	14
00DKA145m	26.11	28.42	drill hole OGS-00-A1	interbedded red and green siltstone and shale (48% coarse/green beds); 3 thin (up to 7mm) gypsum seams	15
00DKA145n	28.42	29.94	drill hole OGS-00-A1	mostly red shale, with some light green and light red siltstone beds (14% coarse/green beds); 2 gypsum seams; 1 large white gypsum nodule @ 29.92 m.	16
00DKA145o	29.94	31.60	drill hole OGS-00-A1	interbedded red and green siltstone, shale, and intraclastic conglomerate (60% coarse/green beds); 1 thin gypsum seam.	17
00DKA145p	31.60	33.70	drill hole OGS-00-A1	mostly red shale with green shale and light green and red siltstone (25% coarse/green beds).	18
00DKA145q	33.70	35.58	drill hole OGS-00-A1	interbedded light green and light red siltstone, red pebble conglomerate and red shale (50% coarse/green beds @ 33.70 - 35.05 m; 10% coarse/green beds @ 35.05 - 35.58 m), 1 gypsum seam.	19, 20
00DKA146a	4.27	6.00	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (50% coarse/green beds in top 1m; 80% coarse/green beds in remainder).	1, 2
00DKA146b	6.00	7.80	drill hole OGS-00-A2	mostly red shale with minor light red and green siltstone and green shale (20% coarse/green beds); a few small vugs (after gypsum?).	3
00DKA146c	7.80	9.48	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (50% coarse/green beds); 1 small vug.	4

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA146d	9.48	11.66	drill hole OGS-00-A2	mostly red shale, with minor red intraclasts, and minor thin (< 6 cm) light green and red siltstone beds (15% coarse/green beds); small vugs in 3 light green beds in top half.	5
00DKA146e	11.66	14.25	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate; more red shale with depth (80% coarse/green beds down to 12.75 m; 25% coarse/green below 12.75 m); couple of small red gypsum nodules.	6, 7
00DKA146f	14.25	15.86	drill hole OGS-00-A2	mostly red shale, with sparse light green siltstone beds (10% coarse/green beds); cluster of small gypsum nodules @ 15.08 - 15.12 m.	8
00DKA146g	15.86	17.42	drill hole OGS-00-A2	15.86 - 16.38: interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (60% coarse/green beds); 16.38 - 17.42: mostly red shale, with thin (< 4 cm) light green siltstone beds and green shale beds (10% coarse/green beds), with small red gypsum(?) nodules.	9, 10
00DKA146h	17.42	18.67	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (50% coarse/green beds); 3 thin gypsum seams.	11
00DKA146i	18.67	19.78	drill hole OGS-00-A2	dark red-maroon shale (mudstone?) with a few thin green shale and siltstone beds (11% coarse/green beds).	12
00DKA146j	19.78	21.93	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (40% coarse/green beds); small red gypsum @ 20.36 m; gypsum seam @ 20.92 m.	13
00DKA146k	21.93	24.00	drill hole OGS-00-A2	mostly dark red shale, with green shale and light green siltstone beds (13% coarse/green beds).	14
00DKA146l	24.00	25.50	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (85% coarse/green beds) down to 24.69 m; mostly red shale (7% coarse/green beds) below 24.69 m; small red gypsum nodule @ 25.19 m.	15, 16
00DKA146m	25.50	26.76	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (65% coarse/green beds); hard beds up to 6 cm thick; 4 thin gypsum seams.	17
00DKA146n	26.76	28.63	drill hole OGS-00-A2	mostly red shale with a few green shale and light green siltstone beds (13% coarse/green beds); a few small to medium red gypsum nodules @ 27.49 m.	18
00DKA146o	28.63	31.60	drill hole OGS-00-A2	interbedded red and green shale, light green and red siltstone (coarse/green beds range from 80% down to 26.57 m, 15% down to 31.20 m, and 70% below 31.20 m); 1 thin gypsum seam @ 31.35 m.	19, 20, 21

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho-logs
	From	To			
00DKA146p	31.60	34.04	drill hole OGS-00-A2	mostly red shale with a few green and light green shale and siltstone beds and mottles (15% coarse/green beds).	22
00DKA146q	34.04	34.87	drill hole OGS-00-A2	interbedded red and green shale, light green and light red siltstone (80% coarse/green beds down to 34.57 m, 10% below 34.57 m); mostly red shale below 34.57 m.	23, 24
00DKA147a	7.46	8.00	drill hole OGS-00-A4	weathered, rubbly, red and green shale and siltstone with clay-coated fractures (~40% coarse/green beds).	1
00DKA147b	8.00	8.77	drill hole OGS-00-A4	mostly red shale with green mottles and shale beds (15% coarse/green beds).	2
00DKA147c	8.77	10.82	drill hole OGS-00-A4	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (60% coarse/green beds); light green beds up to 10 cm thick; 2 small vugs (after gyp?).	3
00DKA147d	10.82	13.18	drill hole OGS-00-A4	mostly red shale, with interbeds of green shale, light green and red siltstone, and minor red pebble conglomerate (22% coarse/green beds); hard beds up to 14 cm thick; a few small vugs (after gypsum?).	4
00DKA147e	13.18	15.93	drill hole OGS-00-A4	interbedded red and green shale, light green and red siltstone, and minor red pebble conglomerate (ranges from 70 to 85% coarse/green beds); thin interval in middle (14.78 - 15.08 m) is mostly red shale (13% coarse/green beds); couple small vugs (after gypsum?).	5, 6, 7
00DKA147f	15.93	18.06	drill hole OGS-00-A4	mostly red shale with green shale beds and red pebble beds (14% coarse/green beds).	8
00DKA147g	18.06	19.73	drill hole OGS-00-A4	interbedded red and green shale, light green and red siltstone, and red pebble conglomerate (55% coarse/green beds; 90% coarse/green beds @ 19.43 - 19.73 m); green siltstone beds up to 20 cm thick; scattered small (< 1cm) red gypsum nodules; couple thin gypsum seams.	9
00DKA147h	19.73	20.58	drill hole OGS-00-A4	red shale with a few light red and light green siltstone, and red pebble conglomerate interbeds (<10% coarse/green beds); with scattered small red gypsum nodules and 1 very thin gypsum seam.	10
00DKA147i	20.58	23.86	drill hole OGS-00-A4	interbedded red shale, light green and red siltstone, and red pebble and mudchip conglomerate (70% coarse/green beds); massive red shale intervals up to 13 cm thick; medium to large white gypsum nodules (e.g., 22.02 m) and small to medium red gypsum nodules (e.g., 21.32 m), and a few white gypsum seams.	11
00DKA147j	23.86	25.63	drill hole OGS-00-A4	red shale with a few light red and light green siltstone beds and green mottles (11% coarse/green beds).	12

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA147k	25.63	28.35	drill hole OGS-00-A4	interbedded red and green shale, light green and red siltstone, and red pebble conglomerate (90% coarse/green beds down to 26.20 m; 50% below 26.20 m); a few thin gypsum seams.	13, 14
00DKA147l	28.35	29.28	drill hole OGS-00-A4	massive red shale with minor green shale and red pebble conglomerate (6% coarse/green beds); large white gypsum nodule @ 28.67 m; couple of gypsum seams.	15
00DKA147m	29.28	30.66	drill hole OGS-00-A4	interbedded light green and light red siltstone, red shale, and minor red pebble conglomerate (45% coarse/green beds); small red gypsum nodule and couple gypsum seams.	16
00DKA147n	30.66	33.04	drill hole OGS-00-A4	mostly red shale with light green and light red siltstone and minor red pebble conglomerate (15% coarse/green beds); sparse small red gypsum nodules.	17
00DKA147o	33.04	34.39	drill hole OGS-00-A4	interbedded light green and light red siltstone, red pebble conglomerate and minor red shale (90% coarse/green beds); one gypsum seam.	18
00DKA147p	34.39	35.60	drill hole OGS-00-A4	mostly red shale with green mottles and sparse light green siltstone beds (17% coarse/green beds).	19
00DKA147q	35.60	36.25	drill hole OGS-00-A4	interbedded light green and light red siltstone, red pebble conglomerate and red shale (80% coarse/green beds); one gypsum seam.	20
00DKA147r	36.25	38.05	drill hole OGS-00-A4	mostly red shale with minor green shale and light green siltstone beds (10% coarse/green beds); small white gypsum nodules @ 36.36 - 36.39 m and 1 gypsum seam.	21
00DKA147s	38.05	38.48	drill hole OGS-00-A4	interbedded light green and red siltstone, and green and red shale, and minor red pebbles (75% coarse/green beds).	22
00DKA148a	6.02	6.55	drill hole OGS-00-A6	mostly massive red shale, with minor green shale and siltstone (14% coarse/green beds); couple vugs (after gyp?).	1
00DKA148b	6.55	9.60	drill hole OGS-00-A6	mostly massive red shale, with minor green shale and siltstone (14% coarse/green beds); couple vugs (after gyp?).	1
00DKA148c	9.60	11.92	drill hole OGS-00-A6	mostly massive red shale, with minor green shale and siltstone (14% coarse/green beds); couple vugs (after gyp?).	1
00DKA148d	11.92	13.37	drill hole OGS-00-A6	interbedded light green and red siltstone, green and red shale, and minor red pebbles; 40 cm green siltstone bed at top and 10 cm bed at base (55% coarse/green beds overall); large composite gypsum nodule and seam in basal 10 cm.	2, 3, 4

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	#
	From	To			
00DKA148e	13.37	16.53	drill hole OGS-00-A6	mostly red shale with some light green and light red siltstone and red pebble conglomerate (20% coarse/green beds); a few gypsum nodules and seam.	5
00DKA148f	16.53	19.03	drill hole OGS-00-A6	mostly red shale with some light green and light red siltstone and red pebble conglomerate (20% coarse/green beds); with abundant gypsum nodules and seams.	6
00DKA148g	19.03	20.11	drill hole OGS-00-A6	interbedded light green and red siltstone, red and green shale, minor red pebble and minor light grey-green medium-grained sandstone (95% coarse/green beds).	7
00DKA148h	20.11	21.62	drill hole OGS-00-A6	red shale with 6 thin light green siltstone interbeds and minor red pebbles (10% coarse/green beds).	8
00DKA148i	21.62	25.46	drill hole OGS-00-A6	interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate (coarse/green beds: 65% @ 21.62 - 22.43 m; 12% @ 22.43 - 24.40 m; 65% 24.40 - 25.46 m); sparse gypsum seams.	9, 10, 11
00DKA148j	25.46	26.10	drill hole OGS-00-A6	interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate and minor grey very siltstone (65% coarse/green beds); a couple medium to large gypsum nodules and a few gypsum seams.	11
00DKA148k	26.10	28.28	drill hole OGS-00-A6	mostly massive red shale with light green siltstone interbeds and minor red pebbles/intracasts (16% coarse/green beds); 1 thin gypsum seam.	12
00DKA148l	28.28	30.94	drill hole OGS-00-A6	interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate (55% coarse/green beds).	13
00DKA148m	30.94	34.24	drill hole OGS-00-A6	mostly red shale and thin light green siltstone beds, with intervals of interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate (32% coarse/green beds).	14
00DKA148n	34.24	37.03	drill hole OGS-00-A6	mostly red shale, with light green siltstone beds and minor interbedded intervals (9% coarse/green beds).	15
00DKA149a	13.94	16.92	drill hole OGS-00-A8	red massive shale @ 13.94 - 14.93 m; light green shale and siltstone @ 14.93 - 15.76 m; red shale with thin light green shale and siltstone beds @ 15.76 - 16.92 m; overall ~33% coarse/green beds.	1, 2, 3
00DKA149b	16.92	18.96	drill hole OGS-00-A8	red shale @ 16.92 - 18.05 m, with small to medium gypsum nodules and seams; interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate (80% coarse/green beds) @ 18.05 - 18.96 m.	4, 5
00DKA149c	18.96	19.32	drill hole OGS-00-A8	interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate (80% coarse/green beds).	5

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic Unit
	From	To			
00DKA149d	19.32	21.90	drill hole OGS-00-A8	mostly massive red shale, with thin green shale and siltstone beds (9% coarse/green beds); minor small gypsum nodules and a few gypsum seams.	6
00DKA149e	21.90	22.70	drill hole OGS-00-A8	interbedded light green and red siltstone, red and green shale, minor red pebble conglomerate (60% coarse/green beds); 2 gypsum seams.	7
00DKA149f	22.70	24.65	drill hole OGS-00-A8	mostly red shale, with minor green shale and siltstone beds (15% coarse/green beds); small gypsum nodules and a couple gypsum seams.	8
00DKA149g	24.65	26.94	drill hole OGS-00-A8	evenly interbedded red shale and thin green shale and siltstone beds (70% coarse/green beds).	9
00DKA149h	26.94	29.36	drill hole OGS-00-A8	massive red shale, with couple green beds (7% coarse/green beds); composite medium-large gypsum nodules @ 27.04 - 27.09 m and 2 gypsum seams.	10
00DKA150a	15.35	17.40	drill hole OGS-00-A10	weathered red shale, with interbeds of light green and red siltstone, green shale, and minor red pebble conglomerate (20% coarse/green beds).	1
00DKA150b	17.40	19.15	drill hole OGS-00-A10	massive red shale with light green mottles (8% coarse/green beds).	2
00DKA150c	19.15	20.61	drill hole OGS-00-A10	interbedded light green and red siltstone, red and green shale, red pebble conglomerate (75% coarse/green beds).	3
00DKA150d	20.61	23.35	drill hole OGS-00-A10	interbedded light green and red siltstone, red and green shale, red pebble conglomerate (75% coarse/green beds).	3
00DKA150e	23.35	24.25	drill hole OGS-00-A10	massive red shale with a few thin (< 3cm) light green shale and siltstone beds (10% coarse/green beds).	4
00DKA150f	24.25	24.76	drill hole OGS-00-A10	interbedded light green and red siltstone, red and green shale, red pebble conglomerate (75% coarse/green beds).	5
00DKA151a	8.46	10.35	drill holes OGS-00-B1	weathered red shale, with small green mottles below 9.90 m (~2% coarse/green beds).	1, 2
00DKA151b	10.35	11.19	drill holes OGS-00-B1	light green shale to argillaceous sandstone with minor light red mottled shale (75% coarse/green beds).	3
00DKA151c	11.19	13.49	drill holes OGS-00-B1	weathered red shale with thin green interbed (3% coarse/green bed).	4
00DKA151d	13.49	14.29	drill holes OGS-00-B1	interbedded light green shale, green siltstone and red shale (30% coarse/green beds).	5
00DKA151e	14.29	17.70	drill holes OGS-00-B1	red shale with light green mottles and minor thin beds (6% coarse/green beds).	6
00DKA151f	17.70	18.30	drill holes OGS-00-B1	light green shale with interbed of light grey-red shale (70% coarse/green beds).	7
00DKA151g	18.30	21.88	drill holes OGS-00-B1	red shale with small green mottles and small white gypsum nodules (<2% coarse/green beds).	8

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- log Unit
	From	To			
00DKA151h	21.88	23.04	drill holes OGS-00-B1	interbedded red and green shale (60% coarse/green beds).	9
00DKA151i	23.04	25.32	drill holes OGS-00-B1	red shale, with a faint light red-green siltstone bed, a few green mottles and sparse small gypsum nodules (<2% coarse/green beds).	
00DKA151j	25.32	26.39	drill holes OGS-00-B1	interbedded green and red shale and siltstone (60% coarse/green beds).	10
00DKA151k	26.39	28.39	drill holes OGS-00-B1	red shale with minor light green and light red siltstone interbeds and very minor small green mottles (<2% coarse/green beds).	11
00DKA151l	28.39	29.02	drill holes OGS-00-B1	interbedded green and red shale and siltstone, and intraclastic (pebbles and mudchips) beds (75% coarse/green beds).	12
00DKA151m	29.02	31.59	drill holes OGS-00-B1	red shale with minor thin light green beds and local small white to light red gypsum nodules (3% coarse/green beds).	13
00DKA151n	31.59	32.94	drill holes OGS-00-B1	interbedded green and red shale, light green and green-red siltstone, and minor intraclastic (pebbles and mudchips) beds (46% coarse/green beds).	14
00DKA151o	32.94	34.43	drill holes OGS-00-B1	mostly massive red shale (<2% coarse/green beds).	15
00DKA151p	34.43	37.52	drill holes OGS-00-B1	mostly massive red shale with green interbeds (<2% coarse/green beds); and minor small white to light red gypsum nodules.	16
00DKA151q	37.52	40.69	drill holes OGS-00-B1	mostly massive red shale with green interbeds (<2% coarse/green beds); and minor small white to light red gypsum nodules.	17
00DKA151r	40.69	41.76	drill holes OGS-00-B1	interbedded green and red shale, light green siltstone, and some red pebble conglomerate beds (90% coarse/green beds); small composite orange gypsum nodules @ 40.95 m; small white gypsum nodules throughout.	17
00DKA151s	41.76	44.82	drill holes OGS-00-B1	mostly red shale, with 4 thin (< 5cm) light green to green siltstone beds (6% coarse/green beds).	18
00DKA151t	44.82	47.19	drill holes OGS-00-B1	44.82 - 45.95 m: interbedded light green siltstone, and green and red shale (35% coarse/green beds) with small to medium gypsum nodules; 45.95 - 47.19 m: mostly red shale, with a faint light green bed and sparse small green mottles (3% coarse/green beds).	19
00DKA151u	47.19	49.28	drill holes OGS-00-B1	47.19 - 48.18 m: interbedded green and red shale, light green siltstone, and some red pebble conglomerate beds (75% coarse/green beds), with minor small gypsum nodules; 48.18 - 49.28 m: mostly red shale with thin green interbeds (10% coarse/green beds), and minor small gypsum nodules.	20, 21
00DKA151v					22, 23

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA151v	49.28	51.15	drill holes OGS-00-B1	interbedded green and red shale, light green siltstone, red pebble and mudchip and minor thin green and red mudstone/shale beds (45% coarse/green beds); significant increase in large gypsum nodules and seams.	24
00DKA151w	51.15	53.08	drill holes OGS-00-B1	red shale, with thin to thick light green interbeds and minor intraclastic beds (17% coarse/green beds); with relatively abundant gypsum nodules and seams.	25
00DKA151x	53.08	55.22	drill holes OGS-00-B1	red shale, with thin to thick light green interbeds and minor intraclastic beds (17% coarse/green beds); with relatively abundant gypsum nodules and seams.	25
00DKA152a	10.59	12.46	drill hole OGS-00-B4	10.59 - 11.26 m: interbedded light green siltstone, green and red shale, and red pebble conglomerate (75% coarse/green beds); 11.26 - 12.46 m: mostly massive red shale, locally sandy (1% coarse/green beds).	1, 2
00DKA152b	12.46	14.04	drill hole OGS-00-B4	12.46 - 13.42 m: interbedded light green and light red siltstone, red and green shale, and red pebble conglomerate (80% coarse/green beds); 13.42 - 14.04 m: massive red sandy shale with light green siltstone and green shale interbeds (26% coarse/green beds).	3, 4
00DKA152c	14.04	16.80	drill hole OGS-00-B4	interbedded light green and light red-green siltstone, red and green shale, and red pebble conglomerate (70% coarse/green beds).	5
00DKA152d	16.80	19.11	drill hole OGS-00-B4	interbedded light green and light red-green siltstone, red and green shale, red pebble and interlaminated red and green siltstone and mudstone intervals (50% coarse/green beds).	6
00DKA152e	19.11	21.92	drill hole OGS-00-B4	interbedded, mostly green, siltstone/limestone and shale (75% coarse/green beds); also red to maroon colour (25%); burrows and mudcracks; some small white fossil fragments.	7
00DKA152f	21.92	23.60	drill hole OGS-00-B4	Georgian Bay Formation: 21.92 - 22.46 m: mostly green mudstone with thin siltstone lenses, burrows and thin beds (28% coarse/green beds); 22.46 - 23.60 m: interbedded light grey-green siltstone/limestone and light green mudstone (74% coarse/green beds), locally thinly interbedded.	8, 9
00DKA152g	23.60	26.55	drill hole OGS-00-B4	Georgian Bay Formation: interbedded green mudstone, light grey-green siltstone/limestone, and light grey-green bioclastic limestone (73% coarse/green beds).	10
00DKA152h	26.55	29.26	drill hole OGS-00-B4	Georgian Bay Formation: interbedded green mudstone, light grey-green siltstone/limestone, and light grey-green bioclastic limestone (66% coarse/green beds); a couple of gypsum seams.	11

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic Unit
	From	To			
00DKA152i	26.66	29.26	drill hole OGS-00-B4	Georgian Bay Fm: mudstone (shale) beds only.	11
00DKA154a	0.00	1.65	drill hole OGS-00-C2	weathered clayey red shale, with minor green intervals (beds or mottles?) (< 10% coarse/green beds).	1
00DKA154b	1.65	4.75	drill hole OGS-00-C2	weathered massive red shale, with a few thin green beds and sparse green mottles (2% coarse/green beds).	2
00DKA154c	4.75	7.80	drill hole OGS-00-C2	weathered massive red shale, with a few thin green beds and sparse green mottles (2% coarse/green beds).	2
00DKA154d	7.80	10.84	drill hole OGS-00-C2	weathered massive red shale, with a few thin green beds and sparse green mottles (2% coarse/green beds).	2
00DKA154e	10.84	12.37	drill hole OGS-00-C2	weathered massive red shale, with a few thin green beds and sparse green mottles (2% coarse/green beds).	2
00DKA154f	12.37	13.24	drill hole OGS-00-C2	12.37 - 12.87 m: red shale with minor thin green mottly beds (4% coarse/green beds); 12.87 - 13.24 m: interbedded light green and red shale, light green siltstone, and red intraclastic conglomerate (40% green and 40% intraclastic beds).	3, 4
00DKA154g	13.24	15.42	drill hole OGS-00-C2	red shale with a few small green mottles (< 2% coarse/green beds).	5
00DKA154h	15.42	17.01	drill hole OGS-00-C2	red shale with a few small green mottles (< 2% coarse/green beds).	5
00DKA154i	17.01	18.47	drill hole OGS-00-C2	red shale with regularly spaced green shale and siltstone interbeds (13% coarse/green beds).	6
00DKA154j	18.47	19.12	drill hole OGS-00-C2	interbedded red and light green shale, light green siltstone, and a bed of bioclastic limestone (40% coarse/green beds); small red gypsum nodules @ 18.66 m.	7
00DKA154k	19.12	20.33	drill hole OGS-00-C2	mostly red shale, with a few thin green beds and mottles (3% coarse/green beds).	8
00DKA154l	20.33	23.26	drill hole OGS-00-C2	20.33 - 20.80 m: interbedded red and light green shale, and light green siltstone (60% coarse/green beds); 1 small red gypsum nod; 20.08 - 21.50 m: red shale with minor coarse beds (6% coarse/green beds); 21.50 - 21.87 m: interbedded red shale (thicker to base), light green shale siltstone, and fine-grained green-grey limestone (40% coarse/green beds); 21.87 - 23.62 m: mostly red shale (4% coarse/green beds).	9, 10, 11, 12
00DKA154m	23.26	23.86	drill hole OGS-00-C2	interbedded red and light green shale, and light green siltstone (10% coarse/green beds); with 2 small red gypsum nodules.	13
00DKA154n	23.86	24.49	drill hole OGS-00-C2	interbedded green shale and grey mudstone, with light green-grey, fine-grained limestone and medium- to coarse-grained, bioclastic limestone (40% coarse/green beds); grain size and thickness of limestone increases with depth.	14

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	Litho- logic Unit
	From	To			
00DKA154o	24.49	26.15	drill hole OGS-00-C2	green, red and grey mudstone (mostly green), with minor thin siltstone/limestone beds (<10% c beds).	15
00DKA154p	26.15	27.23	drill hole OGS-00-C2	interbedded mudstone and limestone (70% limestone); mudstone is mostly green, with minor grey; limestone is fine- to coarse-grained, coarser-grained limestone contains fossil fragments and mudstone rip-ups.	16
00DKA154q	27.23	28.15	drill hole OGS-00-C2	mudstone (mostly green) with thin limestone interbeds (15% limestone); 1 thin gypsum seam.	17
00DKA154r	28.15	29.66	drill hole OGS-00-C2	interbedded limestone, argillaceous limestone and mudstone (70% limestone); mudstone is mostly green, with some black.	18
00DKA154s	29.66	30.35	drill hole OGS-00-C2	green (80%) and red (5%) mudstone, with minor thin limestone beds (15% limestone); thin gypsum seam.	19
00DKA154t	30.35	31.05	drill hole OGS-00-C2	interbedded limestone and mudstone (60% limestone); increasing mudstone with depth; limestone beds up to 6 cm thick; couple gypsum seams.	20
00DKA154u	31.05	33.11	drill hole OGS-00-C2	mostly mudstone (60% red, 30% green, <5% grey), with thin (< 4 cm) light to medium grey, fine- to medium-grained bioclastic limestone interbeds (10% limestone).	21
00DKA154v	33.11	34.11	drill hole OGS-00-C2	interbedded limestone (55%), green (30%), dark grey (5%), and red (10%) mudstone; limestone is more argillaceous in top 25 cm.	22
00DKA154w	34.11	35.70	drill hole OGS-00-C2	mostly mudstone with thin limestone interbeds (10%); a gypsum seam and a small red gypsum nod.	23
00DKA154x	35.70	36.84	drill hole OGS-00-C2	limestone (80%) and green mudstone interbed; with a gypsum seam.	24
00DKA154y	36.84	39.13	drill hole OGS-00-C2	36.84 - 37.70 m: massive green shale (67%) with interbed of red shale, and gypsum seam; 37.70 - 38.36 m: thinly interbedded red (30%) and green (60%) mudstone, and minor thin limestone beds (10%), with a few gypsum seams; 38.36 - 39.13 m: inter-mottled red (80%) and green (20%) massive shale, with thin discontinuous siltstone beds (<5%), 1 gypsum seam and locally abundant small white gypsum nodules.	25, 26, 27
00DKA154z	39.13	41.67	drill hole OGS-00-C2	39.13 - 39.70 m: interlaminated green mudstone (70%), light green siltstone/limestone (30%) and minor red mudstone (<5%), with abundant red and white gypsum nodules and seams; 39.70 - 40.28 m: red (80%) and green (20%) argillaceous silt; with small to medium red and white gypsum nodules; 40.28 - 41.67 m: thinly interbedded green (80%) and red (15%) mudstone and siltstone/limestone (5%), with small to medium gypsum nodules and a thin gypsum seam.	28, 29, 30

Appendix 2: composite sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/ depth (m)		Location Name	Sample Description	# Litho- logic Unit
	From	To			
00DKA154aa	41.67	43.34	drill hole OGS-00-C2	41.67 - 42.60 m: green (50%) and red massive shale, with gypsum seam; 42.60 - 43.05 m: green shale (90%) with thin light green siltstone beds (10%) and small white gypsum nodules; 43.05 - 43.34 m: massive red shale with faint green mottles.	31, 32, 33
00DKA154ab	43.34	46.02	drill hole OGS-00-C2	43.34 - 44.08 m: green shale with light green siltstone (20%), small red and large white gypsum nodules and seams; 44.08 - 44.15 m: red pebble conglomerate with white gypsum nod; 44.15 - 44.61 m: red shale with faint green mottling (15%), and small to large, light red to white gypsum nodules and seam; 44.61 - 44.82 m: massive red shale with small white gypsum nodules at top; 44.82 - 45.35 m: green shale with minor (<10%) red mottles and beds, and with some white gypsum nodules and seams; 45.35 - 46.02 m: red shale, with green (60%) shale beds and mottles, and with gypsum seams and nodules.	34, 35, 36, 37, 38, 39
00DKA154ac	46.02	48.94	drill hole OGS-00-C2	46.02 - 46.47 m: red shale with minor green mottles and some small white gypsum nodules and thin gypsum seams; 46.47 - 47.35 m: green shale (60%) with red mottly beds (20%), light green siltstone (10%), minor red pebble conglomerate (~5%), and red laminated mudstone (<5%), with small to medium white gypsum nodules and seams; 47.35 - 48.06 m: red shale with minor (<10%) green mottles and sparse small white gypsum nodules; 48.06 - 48.94 m: interbedded green shale (50%), red shale (30%), light green siltstone (15%), and red pebble conglomerate (5%), with gypsum seams and white and orange gypsum nodules.	40, 41, 42, 43

APPENDIX 3

Bed sample information (modified after Armstrong 2001).

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Litho- logic Unit #
	From	To			
00DKA001a	33.90	34.00	OGS-83-1 (Milton core)	green shale	1
00DKA001b	40.00	40.10	OGS-83-1 (Milton core)	red shale - part rubbly	3
00DKA001c	50.00	50.10	OGS-83-1 (Milton core)	red shale - part rubbly	3
00DKA001d	60.00	60.10	OGS-83-1 (Milton core)	red shale	6
00DKA001e	70.00	70.10	OGS-83-1 (Milton core)	red shale - with large green mottle/bed (2% green)	6
00DKA001f	80.00	80.10	OGS-83-1 (Milton core)	red shale with thin (3.5 cm) light green siltstone at base with low angle to horizontal lamination	7
00DKA001g	89.70	90.10	OGS-83-1 (Milton core)	green siltstone and red shale (~30%) with gypsum nodules and sub-horizontal fractures (immediately above a 1 cm horizontal gypsum seam)	11
00DKA001h	100.00	100.10	OGS-83-1 (Milton core)	red shale and green siltstone (40%) with minor small gypsum nodules.	11
00DKA001i	110.00	110.10	OGS-83-1 (Milton core)	red shale to siltstone with green siltstone (<25%)	12
00DKA001j	114.96	115.06	OGS-83-1 (Milton core)	red shale with green mottles (<10%)	13
00DKA001k	119.93	120.04	OGS-83-1 (Milton core)	red shale with round red clasts	16
00DKA001l	125.00	125.12	OGS-83-1 (Milton core)	red shale	16
00DKA001m	129.93	130.03	OGS-83-1 (Milton core)	intraclastic light and dark red shale/conglomerate and light green siltstone at base (<25%)	16
00DKA001n	134.97	135.07	OGS-83-1 (Milton core)	light green siltstone (75%) with low angle cross-lamination, and red shale (25%)	16
00DKA001o	139.92	140.02	OGS-83-1 (Milton core)	light green to green siltstone (40%), intraclastic red shale (40%) and light red laminated siltstone (20%)	16
00DKA001p	144.95	145.08	OGS-83-1 (Milton core)	light green, low angle laminated siltstone (90%), and red intraclastic shale (10%)	16
00DKA001q	149.99	150.10	OGS-83-1 (Milton core)	light green low angle laminated siltstone (70%), green shale (15%), and red shale (15%)	17
00DKA001r	155.07	155.18	OGS-83-1 (Milton core)	mottly red (50%) and green (50%) siltstone and shale - disturbed laminae in green bed	17
00DKA001s	160.01	160.11	OGS-83-1 (Milton core)	red shale and light green and red, low angle laminated, siltstone (20%), and mixed light red and light green siltstone (25%), and small green mottles.	17
00DKA001t	164.98	165.10	OGS-83-1 (Milton core)	massive red shale with red intraclasts in basal 3 cm.	17
00DKA001u	169.97	170.07	OGS-83-1 (Milton core)	massive red shale	17

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Litho-logic Unit #
	From	To			
00DKA001v	175.01	175.11	OGS-83-1 (Milton core)	interlaminated red (35%), light red (20%), green (25%), light green (20%) shale and siltstone.	18
00DKA001w	178.67	178.77	OGS-83-1 (Milton core)	red fissile mudstone with thin light red siltstone interbeds.	18
00DKA001x	179.96	180.07	OGS-83-1 (Milton core)	red mudstone (60%) and green mudstone siltstone (30%) and thin light green shale (10%)	18
00DKA001y	181.53	181.67	OGS-83-1 (Milton core)	horizontally and cross-laminated, light red siltstone (75%) and thin red mudstone interbeds (25%)	19
00DKA001z	185.02	185.16	OGS-83-1 (Milton core)	green shale/mudstone (Georgian Bay Fm)	21
00DKA001aa	190.03	190.23	OGS-83-1 (Milton core)	interbedded light green limestone and dark green shale/ mudstone (Georgian Bay Fm)	21
00DKA002a	1.75	1.80	Burlington Quarry	horizontally laminated, light red siltstone	2
00DKA002b	1.20	1.30	Burlington Quarry	red shale	2
00DKA002c	3.05	3.15	Burlington Quarry	grey, fine-grained limestone	4
00DKA002d	5.20	5.30	Burlington Quarry	grey-green limestone, with green mudstone partings	4
00DKA002e	4.20	4.30	Burlington Quarry	red shale, with light red and green siltstone.	4
00DKA002f	5.40	5.60	Burlington Quarry	red shale	5
00DKA002g	6.15	6.20	Burlington Quarry	light green-red siltstone	5
00DKA002h	6.45	6.50	Burlington Quarry	green to brown-red, siltstone/limestone?	5
00DKA002i	6.60	6.65	Burlington Quarry	green shale/sandstone	5
00DKA002j	8.65	8.75	Burlington Quarry	red shale and siltstone.	5
00DKA002k	9.05	9.20	Burlington Quarry	red shale	6
00DKA002l	10.45	10.55	Burlington Quarry	red shale	6
00DKA002m	11.35	11.45	Burlington Quarry	laminated siltstone	6
00DKA002n	11.90	12.05	Burlington Quarry	red shale with thin hard bed	6
00DKA002o	14.05	14.15	Burlington Quarry	red shale	7
00DKA002p	14.75	14.80	Burlington Quarry	red siltstone	7
00DKA002q	15.35	15.45	Burlington Quarry	green limestone bed at top of unit 7	7
00DKA003a	-0.10	0.00	Cheltenham Quarry	green : siltstone, with red mottle	1
00DKA003b	2.60	2.70	Cheltenham Quarry	gypsum nodules and fracture in red shale	2
00DKA003c	5.25	5.45	Cheltenham Quarry	red shale with gypsum nodules	4
00DKA003d	6.30	6.35	Cheltenham Quarry	green siltstone bed near top of unit, with small scale cross-lamination	4

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Litho- logic #
	From	To			
00DKA003e	9.20	9.40	Cheltenham Quarry	red shale	5
00DKA003f	13.00	13.15	Cheltenham Quarry	green shale, under green hard bed	5
00DKA003g	13.00	13.15	Cheltenham Quarry	red shale, 1.4 m to west of sample 00DKA-003f	5
00DKA003h	16.80	16.85	Cheltenham Quarry	green, argillaceous, fine-grained limestone	5
00DKA003i	18.55	18.65	Cheltenham Quarry	red shale	6
00DKA003j	19.95	20.05	Cheltenham Quarry	green shale and siltstone	6
00DKA004a	-0.20	0.00	Milton Quarry	green shale/ sandstone	1
00DKA004b	0.25	0.35	Milton Quarry	red shale	2
00DKA004c	3.80	3.90	Milton Quarry	red shale	2
00DKA004d	4.95	5.05	Milton Quarry	green shale and siltstone	3
00DKA004e	6.10	6.20	Milton Quarry	red shale	4
00DKA004f	10.00	10.10	Milton Quarry	red shale with small green mottles	6
00DKA004g	12.60	12.70	Milton Quarry	green bed at top of unit 6	6
00DKA004h	15.20	15.40	Milton Quarry	red shale	7
00DKA004i	16.30	16.40	Milton Quarry	green bed at top of unit 7	7
00DKA004k	19.00	19.30	Milton Quarry	red-brown shale with small green mottles	8
00DKA004l	22.90	23.00	Milton Quarry	typical red-brown shale	9
00DKA004m	23.90	24.00	Milton Quarry	green bed at top of unit 9	9
00DKA004n	25.40	25.50	Milton Quarry	red-brown shale	10
00DKA005a	0.75	0.80	Mount Pleasant	red shale	1
00DKA005b	1.75	1.80	Mount Pleasant	green limestone and green shale at base of unit 2	2
00DKA005c	2.25	2.35	Mount Pleasant	weathered red shale	2
00DKA005d	3.50	3.60	Mount Pleasant	red-brown shale	3
00DKA006a	2.00	2.10	A.C. Martin Quarry	red shale	1
00DKA006b	2.05	2.15	A.C. Martin Quarry	green shale in large green mottle, beside sample 00DKA-006a	1
00DKA006c	2.20	2.25	A.C. Martin Quarry	green hard bed	1
00DKA006d	3.75	3.85	A.C. Martin Quarry	red shale	2
00DKA006e	6.60	6.70	A.C. Martin Quarry	red shale	3
00DKA006f	9.25	9.35	A.C. Martin Quarry	red shale	3
00DKA007e	0.10	0.15	Streetsville Quarry	fine- to medium-grained, red limestone	2
00DKA007f	0.95	1.05	Streetsville Quarry	red and green shale and minor siltstone	2

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Litho- logi- Unit #
	From	To			
00DKA007i	3.60	3.70	Streetsville Quarry	red shale	5
00DKA007m	3.80	3.90	Streetsville Quarry	green shale	5
00DKA007o	6.55	6.58	Streetsville Quarry	green siltstone	7
00DKA007p	7.10	7.15	Streetsville Quarry	green siltstone/limestone?	8
00DKA007r	8.20	8.25	Streetsville Quarry	green shale, with minor red mottling	9
00DKA007s	10.50	10.60	Streetsville Quarry	red shale	10
00DKA007u	13.30	13.40	Streetsville Quarry	green argillaceous limestone	11
00DKA007v	13.60	13.70	Streetsville Quarry	red shale	11
00DKA007w	14.85	14.95	Streetsville Quarry	red shale and laminated siltstone	12
00DKA007x	14.95	15.00	Streetsville Quarry	green siltstone	12
00DKA007y	17.50	17.60	Streetsville Quarry	weathered red shale	12
00DKA007z	14.35	14.45	Streetsville Quarry	hard, red shale	12
00DKA008a	0.00	0.20	Cheltenham Badlands	red shale	1
00DKA008b	3.00	3.10	Cheltenham Badlands	red shale	1
00DKA008c	6.00	6.10	Cheltenham Badlands	red shale	2
00DKA008d	9.00	9.10	Cheltenham Badlands	red shale	3
00DKA008e	12.00	12.10	Cheltenham Badlands	red shale, immediately below green bed	3
00DKA008f	15.00	15.10	Cheltenham Badlands	red shale	5
00DKA008g	18.00	18.10	Cheltenham Badlands	red shale	5
00DKA008h	21.00	21.10	Cheltenham Badlands	red shale	5
00DKA008i	7.05	7.10	Cheltenham Badlands	green sandy, shale	3
00DKA008j	10.40	10.50	Cheltenham Badlands	green shale	5
00DKA008k	19.00	19.10	Cheltenham Badlands	green shale related to vertical fracture	5
00DKA010a	0.05	0.10	Georgetown - Credit River, across from old mill	green shale and limestone	1
00DKA010b	0.50	0.70	Georgetown - Credit River, across from old mill	red shale	1
00DKA010c	0.85	1.00	Georgetown - Credit River, across from old mill	red shale	1
00DKA010d	1.20	1.25	Georgetown - Credit River, across from old mill	green argillaceous limestone with horizontal lamination	1

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	# Litho-logic Unit
	From	To			
00DKA010e	4.15	4.25	Georgetown - Credit River, across from old mill	red shale	2
00DKA010f	5.10	5.15	Georgetown - Credit River, across from old mill	green limestone	2
00DKA011a	0.00	0.05	Georgetown - Credit River, NW of ruins	grey-green argillaceous limestone	1
00DKA011b	0.50	0.60	Georgetown - Credit River, NW of ruins	grey-green limestone hard bed, with faint lamination	3
00DKA011c	0.80	0.85	Georgetown - Credit River, NW of ruins	green to red-grey siltstone	4
00DKA011d	1.10	1.20	Georgetown - Credit River, NW of ruins	red shale	4
00DKA011f	2.25	2.30	Georgetown - Credit River, NW of ruins	grey-green argillaceous limestone	6
00DKA011g	2.75	2.80	Georgetown - Credit River, NW of ruins	green very argillaceous limestone	6
00DKA012a	1.20	1.40	Credit River valley, west of Huttonville	red shale with minor thin green bed	1
00DKA013a	0.25	0.35	Credit River, 1km west Huttonville	red shale	1
00DKA013b	1.25	1.30	Credit River, 1km west Huttonville	basal green limestone bed of unit 2	2
00DKA013c	2.65	2.75	Credit River, 1km west Huttonville	red shale	2
00DKA014a	-0.40	-0.35	Aldershot Brickplant	green argillaceous limestone with horizontal and ripple cross-lamination	1
00DKA014b	0.10	0.25	Aldershot Brickplant	red shale	1
00DKA014c	0.25	0.40	Aldershot Brickplant	green very argillaceous limestone	1
00DKA014d	1.30	1.40	Aldershot Brickplant	red shale with small gypsum nodules (and gypsum fracture?)	2
00DKA014f	4.60	4.75	Aldershot Brickplant	red shale	3
00DKA014g	8.30	8.45	Aldershot Brickplant	green shale	5
00DKA014h	8.45	8.50	Aldershot Brickplant	green cross-laminated siltstone in basal bed of unit	5

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Lithology
	From	To			
00DKA014i	12.00	12.10	Aldershot Brickplant	red shale	6
00DKA014j	14.25	14.35	Aldershot Brickplant	red shale	7
00DKA014k	16.00	16.10	Aldershot Brickplant	red shale	7
00DKA014l	16.30	16.40	Aldershot Brickplant	green argillaceous siltstone	7
00DKA014m	17.10	17.20	Aldershot Brickplant	red shale	8
00DKA014n	18.35	18.45	Aldershot Brickplant	red clayey shale	8
00DKA015a	0.00	0.55	Aldershot west site - north end of property	red (60%) and green (40%) shale - composite of section in ditch	1
00DKA016a	0.40	0.50	Aldershot west site, north end, SW of 00DKA015	red shale	1
00DKA017a	2.00	2.10	Aldershot west site - ravine trail section	red shale	1
00DKA017b	3.35	3.45	Aldershot west site - ravine trail section	red shale	1
00DKA017c	10.95	11.05	Aldershot west site - ravine trail section	red shale and 1 green mottle	2
00DKA017d	13.95	14.05	Aldershot west site - ravine trail section	red shale	2
00DKA017e	16.95	17.05	Aldershot west site - ravine trail section	red shale	2
00DKA018a	0.40	0.50	Aldershot east site - ravine at north end	red shale	1
00DKA018b	1.40	1.50	Aldershot east site - ravine at n. end	red shale with thin green bed at base	1
00DKA018c	2.90	3.00	Aldershot east site - ravine at n. end	red shale with thin (<3 cm) green mottly bed at base	1
00DKA018d	4.50	4.60	Aldershot east site - ravine at n. end	green shale mottle, with some red shale	1
00DKA018e	5.60	5.65	Aldershot east site - ravine at n. end	green bed	1

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA018f	6.00	6.10	Aldershot east site - ravine at n. end	red shale	1
00DKA018g	7.50	7.60	Aldershot east site - ravine at n. end	red shale	2
00DKA018h	9.00	9.10	Aldershot east site - ravine at n. end	red shale with small green mottles	2
00DKA018i	9.90	10.00	Aldershot east site - ravine at n. end	thin green bed	2
00DKA018j	10.50	10.60	Aldershot east site - ravine at n. end	red shale and 1 green mottle	2
00DKA018k	12.00	12.10	Aldershot east site - ravine at n. end	red shale with green mottles	2
00DKA019a	0.25	0.40	Bayview Quarry	blue-green clayey mudstone; top of Queenston Fm or Whirlpool Fm (see drill hole OGS-00-C1)	1
00DKA020a	0.00	0.10	Irish Mountain Lookout	red shale	1
00DKA020b	1.50	1.60	Irish Mountain Lookout	red shale	1
00DKA020c	2.25	2.35	Irish Mountain Lookout	green shale	1
00DKA020d	3.00	3.05	Irish Mountain Lookout	light green, argillaceous, siltstone	2
00DKA020e	4.55	4.65	Irish Mountain Lookout	green shale	3
00DKA025a	0.00	0.20	Big Bay road cut	green shale/mudstone	1
00DKA025b	0.20	0.25	Big Bay road cut	red and green, laminated, argillaceous, very siltstone	1
00DKA025d	1.40	1.45	Big Bay road cut	red, faintly laminated, argillaceous sandstone bed	2
00DKA025e	3.20	3.30	Big Bay road cut	red and green shale	3
00DKA025g	5.70	5.80	Big Bay road cut	red shale	4
00DKA025i	12.00	12.10	Big Bay road cut	mostly green shale, under limestone bed	7
00DKA025m	12.30	12.40	Big Bay road cut	grey limestone, with vertical green burrows, some fossils	7
00DKA025o	14.80	15.00	Big Bay road cut	red and green clayey shale/mudstone, with thin, minor limestone bed in middle	7
00DKA025p	15.50	15.60	Big Bay road cut	dark grey limestone, with green vertical burrows	8
00DKA026a	0.00	0.20	Owen Sound East	red-brown shale	1
00DKA026b	1.40	1.50	Owen Sound East	red shale	1
00DKA026c	2.80	2.85	Owen Sound East	green hard bed	1

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	# Litho- logic
	From	To			
00DKA026d	3.90	4.00	Owen Sound East	red shale	1
00DKA026e	5.55	5.65	Owen Sound East	red shale, over green bed	1
00DKA026f	12.60	12.75	Owen Sound East	grey-green and red shale	1
00DKA026g	14.10	14.25	Owen Sound East	green clayey siltstone/mudstone	1
00DKA027a	0.00	0.01	7 Sideroad, south of Meaford	red-brown shale, slightly clayey	1
00DKA027b	2.90	3.00	7 Sideroad, south of Meaford	green shale and thin green hard bed	1
00DKA027c	10.25	10.35	7 Sideroad, south of Meaford	red-brown shale, blocky, minor green bed at base	1
00DKA027d	14.85	14.95	7 Sideroad, south of Meaford	red shale	1
00DKA027e	18.50	18.70	7 Sideroad, south of Meaford	green shale and hard bed, and light red-green shale	1
00DKA027f	19.90	20.00	7 Sideroad, south of Meaford	red shale, crumbly	1
00DKA028a	0.00	0.30	Grey County Rd 7, south of Meaford	composite of red and green clayey shale	1
00DKA029a	0.00	0.10	Ten Hill, north of Creemore	weathered red clay/mudstone, from water-filled ditch	1
00DKA030a	0.00	0.10	road south of Creemore	red shale, crumbly	1
00DKA030b	1.40	1.50	road south of Creemore	red clayey, shale; crumbly	1
00DKA031a	0.00	0.30	Mulmur Twp, w of Mansfield	red shale; small blocky	1
00DKA031b	3.65	3.80	Mulmur Twp, w of Mansfield	green (3 cm) and red (12 cm) shale beds	1
00DKA031c	7.60	7.75	Mulmur Twp, w of Mansfield	red, crumbly, shale, near top of section	1
00DKA031d	1.00	1.50	Mulmur Twp, w of Mansfield - lower section	red shale, minor green mottles	1
00DKA031e	2.50	2.55	Mulmur Twp, w of Mansfield - lower section	green, laminated limestone; capping lower section	1
00DKA032a	1.50	1.60	Hockley Valley, Road 7	red shale	1
00DKA032b	2.90	3.00	Hockley Valley, Road 7	red shale	1
00DKA032c	3.80	3.90	Hockley Valley, Road 7	green and red shale	2

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	# Litho-log Unit
	From	To			
00DKA032d	5.60	5.70	Hockley Valley, Road 7	red shale	3
00DKA032e	7.55	7.66	Hockley Valley, Road 7	green bed in middle of unit 4	4
00DKA032f	11.20	11.30	Hockley Valley, Road 7	red shale	5
00DKA033a	0.50	0.60	Bronte Creek, s of QEW, w of Bronte Rd	green sandy shale	1
00DKA033b	0.90	1.10	Bronte Creek, s of QEW, w of Bronte Rd	red shale	1
00DKA034b	1.60	1.80	Sixteen Mile Ck, Lion's Valley Pk	red shale	1
00DKA036c	1.25	1.50	Bronte Ck, NW of Zimmerman	red shale	3
00DKA036d	1.80	1.85	Bronte Ck, NW of Zimmerman	hard bed with low angle to horizontal lamination	3
00DKA037a	0.20	0.25	Bronte Creek, n. of QEW, w. of Bronte Rd	green, ripple-laminated, siltstone bed	1
00DKA037b	0.60	0.80	Bronte Creek, n. of QEW, w. of Bronte Rd	red shale	2
00DKA037c	1.75	1.80	Bronte Creek, n. of QEW, w. of Bronte Rd	red hard bed, with ripple cross-lamination and rip-ups	3
00DKA038b	7.95	8.05	Sixteen Mile Creek at HWY 407	red shale	3
00DKA040a	3.25	3.35	Sixteen Mile Creek at HWY 407 - access road	red shale	1
00DKA040b	3.25	3.35	Sixteen Mile Creek at HWY 407 - access road	red shale	1
00DKA040c	1.20	1.30	Sixteen Mile Creek at HWY 407 - access road	green argillaceous limestone(?), with faint lamination	1
00DKA040e	7.00	7.20	Sixteen Mile Creek at HWY 407 - access road	red shale	3
00DKA040f	8.20	8.25	Sixteen Mile Creek at HWY 407 - access road	red hard bed, with faint horizontal lamination	3

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Litho-logic Unit #
	From	To			
00DKA040h	11.40	11.50	Sixteen Mile Creek at HWY 407 - access road	light red-green, very hard bed/limestone; capping solid bedrock	5
00DKA041a	0.40	0.50	Grindstone Ck & Falls, Waterdown	red shale	1
00DKA041b	1.10	1.20	Grindstone Ck & Falls, Waterdown	green shale	1
00DKA041c	1.40	1.60	Grindstone Ck & Falls, Waterdown	red shale	1
00DKA042a	0.10	0.20	Devil's Punchbowl, Stoney Creek	red shale, with green mottles and small (< 1 cm) gypsum nodules.	1
00DKA042b	0.90	0.95	Devil's Punchbowl, Stoney Creek	green bed	1
00DKA042c	2.95	3.05	Devil's Punchbowl, Stoney Creek	red shale with green mottles	1
00DKA042d	5.15	5.25	Devil's Punchbowl, Stoney Creek	green shale, with horizontal lamination	1
00DKA042e	5.90	6.00	Devil's Punchbowl, Stoney Creek	red shale	1
00DKA042f	9.00	9.10	Devil's Punchbowl, Stoney Creek	red shale	1
00DKA042g	11.90	12.10	Devil's Punchbowl, Stoney Creek	red shale, with green mottles	1
00DKA042h	12.50	12.60	Devil's Punchbowl, Stoney Creek	thick green bed, with planar lamination	1
00DKA042i	13.50	13.60	Devil's Punchbowl, Stoney Creek	red shale	1
00DKA042j	14.50	14.80	Devil's Punchbowl, Stoney Creek	green shale; immediately below contact with Whirlpool Fm	1
00DKA043a	89.94	90.04	Niagara Falls OPG core #NF-33	red shale with green mottles	1

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	# Litho-logic
	From	To			
00DKA043b	94.61	94.70	Niagara Falls OPG core #NF-33	green argillaceous siltstone	1
00DKA043c	99.74	99.83	Niagara Falls OPG core #NF-33	red shale	1
00DKA043d	109.80	109.90	Niagara Falls OPG core #NF-33	red shale	1
00DKA043e	118.39	118.50	Niagara Falls OPG core #NF-33	green shale	2
00DKA043f	119.86	120.00	Niagara Falls OPG core #NF-33	green siltstone with red mottled	2
00DKA043g	129.78	129.90	Niagara Falls OPG core #NF-33	red shale with 3 cm green shale at bottom	3
00DKA043h	139.84	140.00	Niagara Falls OPG core #NF-33	green/red/green siltstone (50:50 red:green)	4
00DKA043i	141.83	142.00	Niagara Falls OPG core	red shale with abundant composite gypsum nodules	4
00DKA043j	149.40	149.50	Niagara Falls OPG core	green shale/sandstone	4
00DKA043k	149.86	150.00	Niagara Falls OPG core	red shale	4
00DKA043l	158.04	158.10	Niagara Falls OPG core	red shale	5
00DKA043m	159.70	159.80	Niagara Falls OPG core	green, cross-laminated, siltstone with green shale at base	5
00DKA043n	169.69	169.80	Niagara Falls OPG core	red shale	5
00DKA043o	178.49	178.60	Niagara Falls OPG core	red shale with small gypsum nodules	5
00DKA043p	179.83	179.90	Niagara Falls OPG core	mostly red shale; small gypsum nodule just below	5
00DKA043q	189.71	189.80	Niagara Falls OPG core	red shale	5
00DKA043r	193.69	193.80	Niagara Falls OPG core	red shale with green bed in middle	5
00DKA043s	199.76	199.90	Niagara Falls OPG core	red with green	5
00DKA043t	209.72	209.80	Niagara Falls OPG core	dark and light red	6
00DKA043u	210.25	210.40	Niagara Falls OPG core	light green over light red, with sharp base over dark red; sub-horizontal lamination	6
00DKA043v	215.20	215.40	Niagara Falls OPG core	thinly interbedded light and dark red	6
00DKA043w	219.82	220.00	Niagara Falls OPG core	red shale	6
00DKA043x	222.43	222.50	Niagara Falls OPG core	light green, siltstone in red shale	6

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	# Lithologic Units
	From	To			
00DKA043y	226.35	226.50	Niagara Falls OPG core	light green siltstone with low angle lamination	7
00DKA043z	228.30	228.40	Niagara Falls OPG core	red shale	7
00DKA043aa	228.15	228.26	Niagara Falls OPG core	red shale with 4 cm green bed base	7
00DKA053a	1.88	1.98	drill hole OGS-00-C1	Whirlpool Fm: thinly interbedded light grey sandstone (90%) (up to 1 cm thick) and green mudstone (10%)	not det
00DKA053b	4.92	5.03	drill hole OGS-00-C1	red shale with small green mottles (<10%)	not det
00DKA053c	7.98	8.08	drill hole OGS-00-C1	red shale with medium green mottles (20%)	not det
00DKA053d	11.02	11.12	drill hole OGS-00-C1	massive red shale	not det
00DKA053e	14.07	14.17	drill hole OGS-00-C1	massive red shale	not det
00DKA053f	17.12	17.22	drill hole OGS-00-C1	massive red shale	not det
00DKA053g	20.17	20.27	drill hole OGS-00-C1	rubby, clay-coated, massive red shale	not det
00DKA053h	23.22	23.32	drill hole OGS-00-C1	massive red shale	not det
00DKA053i	26.27	26.36	drill hole OGS-00-C1	massive red shale with medium green mottles	not det
00DKA053j	29.31	29.41	drill hole OGS-00-C1	massive red shale	not det
00DKA053k	32.36	32.46	drill hole OGS-00-C1	massive red shale with small green mottles (small gypsum nodules above sample)	not det
00DKA053l	35.41	35.51	drill hole OGS-00-C1	massive red shale	not det
00DKA053m	38.45	38.55	drill hole OGS-00-C1	6 cm green mudstone and light green siltstone, over 4 cm maroon mudstone	not det
00DKA053n	41.50	41.60	drill hole OGS-00-C1	massive red shale	not det
00DKA053o	43.03	43.13	drill hole OGS-00-C1	medium- to coarse-grained argillaceous limestone	not det
00DKA053p	44.55	44.65	drill hole OGS-00-C1	green shale with minor red mottles	not det
00DKA053q	47.60	47.70	drill hole OGS-00-C1	green (30%) and light red shale (50%) and limestone (20%)	not det
00DKA053r	50.65	50.75	drill hole OGS-00-C1	green shale (60%), thin red mottles (10%), thin light grey-green limestone beds (30%)	not det
00DKA053s	53.69	53.79	drill hole OGS-00-C1	red shale (55%), green shale (30%), and gypsum seam (15%)	not det
00DKA053t	56.74	56.84	drill hole OGS-00-C1	red shale with gypsum nodule and seam in green mottle	not det
00DKA053u	59.79	59.89	drill hole OGS-00-C1	mottly red (55%) and green (40%) shale with gypsum seams (5%)	not det
00DKA053v	62.84	62.94	drill hole OGS-00-C1	red shale (75%), minor green shale (10%), orange gypsum nodule (15%)	not det
00DKA053w	65.88	65.98	drill hole OGS-00-C1	green shale (95%) with thin gypsum seam (5%)	not det
00DKA053x	68.93	69.03	drill hole OGS-00-C1	interlaminated red, light red and light green mudstone, shale and siltstone	not det
00DKA053y	71.98	72.08	drill hole OGS-00-C1	light green-grey siltstone (30%) and red shale (70%)	not det

Appendix 3: bed sample information (see Appendix 1 for detailed station locations; double lines separate samples from different stations).

Sample #	Elevation/depth (m)		Location Name	Sample Description	Litho- logic #
	From	To			
00DKA053z	75.03	75.13	drill hole OGS-00-C1	grey limestone (45%), green mudstone (40%), and argillaceous limestone (15%)	not det

APPENDIX 4

Major and minor element data for composite samples (modified after Armstrong 2001).

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA102a	44.99	10.71	0.13	2.94	15.45	0.73	3.12	0.15	0.58	4.43	16.14	99.37	13.00	0.03
00DKA102b	47.13	10.78	0.14	2.91	14.06	0.82	2.75	0.15	0.63	4.24	15.34	98.96	12.10	0.02
00DKA102c	50.82	11.33	0.13	2.68	11.88	0.95	2.95	0.16	0.67	4.29	13.41	99.26	9.98	0.06
00DKA102d	42.74	9.02	0.15	2.73	18.63	0.80	2.66	0.16	0.56	3.73	18.45	99.64	15.60	0.03
00DKA102e	42.97	9.25	0.15	2.78	18.19	0.78	2.72	0.15	0.54	3.89	18.31	99.73	15.25	0.03
00DKA102f	42.43	9.05	0.15	2.70	18.54	0.74	2.74	0.16	0.54	3.81	18.51	99.37	15.45	0.03
00DKA102g	45.82	11.12	0.13	2.61	14.69	0.72	2.85	0.16	0.60	4.34	16.17	99.22	12.30	0.03
00DKA103a	42.77	9.28	0.14	3.10	18.19	0.52	2.90	0.18	0.55	3.32	18.63	99.59	15.50	0.03
00DKA103b	45.89	12.31	0.11	2.98	12.32	0.32	3.39	0.15	0.63	5.06	16.02	99.18	10.50	0.02
00DKA103c	44.28	12.73	0.11	3.20	13.26	0.20	3.56	0.15	0.61	5.06	15.76	98.92	11.23	0.09
00DKA103d	48.25	13.89	0.11	3.55	9.47	0.19	4.08	0.14	0.69	5.69	13.55	99.60	8.30	0.01
00DKA103e	48.58	13.91	0.10	3.38	8.82	0.16	4.11	0.14	0.69	5.83	13.50	99.21	7.66	n.d.
00DKA104a	51.49	14.50	0.10	3.41	7.19	0.27	4.34	0.14	0.74	6.09	11.23	99.49	6.26	0.02
00DKA104b	49.85	12.24	0.11	3.08	11.39	0.42	3.52	0.14	0.65	3.85	13.65	98.90	9.82	0.02
00DKA104c	49.75	14.17	0.10	3.32	8.37	0.21	4.21	0.14	0.71	5.86	12.05	98.90	7.24	0.01
00DKA104d	53.15	14.79	0.09	3.32	5.73	0.26	4.47	0.15	0.76	6.24	10.62	99.57	4.99	n.d.
00DKA104e	52.51	14.69	0.09	3.54	6.20	0.27	4.48	0.14	0.76	6.15	10.89	99.71	5.54	0.01
00DKA104f	50.27	13.98	0.10	3.42	8.33	0.21	4.20	0.14	0.71	5.68	12.35	99.39	7.39	0.01
00DKA104g	51.00	13.88	0.10	3.56	8.31	0.24	4.23	0.15	0.71	5.73	11.22	99.13	7.40	0.01
00DKA104h	49.58	14.67	0.11	3.96	7.73	0.12	4.51	0.14	0.71	6.44	11.40	99.37	7.16	n.d.
00DKA104i	49.52	15.41	0.11	4.16	6.43	0.12	4.78	0.14	0.72	6.84	10.68	98.90	6.24	n.d.
00DKA105a	40.63	11.58	0.11	2.86	16.79	0.31	3.80	0.14	0.54	5.20	17.20	99.15	13.50	0.02
00DKA105b	36.14	8.27	0.16	2.30	24.31	0.51	2.59	0.14	0.44	2.80	22.00	99.65	19.20	0.03
00DKA105c	48.13	13.69	0.09	2.89	11.00	0.41	3.82	0.15	0.67	5.80	12.74	99.39	8.92	0.04
00DKA106a	51.31	14.26	0.10	3.66	7.93	0.13	4.39	0.14	0.73	5.92	11.06	99.62	7.07	0.01
00DKA106b	52.05	14.75	0.10	3.82	6.66	0.14	4.60	0.14	0.75	6.36	10.37	99.73	6.18	n.d.
00DKA106c	47.71	14.41	0.10	3.87	9.08	0.13	4.32	0.14	0.68	6.30	12.79	99.54	8.35	n.d.
00DKA107a	58.57	9.54	0.13	1.79	10.27	1.15	2.34	0.15	0.61	4.41	10.58	99.54	8.15	0.02
00DKA107b	58.97	14.06	0.07	2.71	3.97	0.83	3.99	0.15	0.80	6.83	6.91	99.28	3.19	0.01
00DKA107c	48.13	8.44	0.20	2.25	16.79	0.86	2.39	0.13	0.46	3.89	16.05	99.58	13.70	0.02
00DKA107d	58.72	15.33	0.06	2.99	2.82	0.61	4.43	0.15	0.82	7.66	6.31	99.88	2.33	n.d.
00DKA107e	51.76	8.14	0.19	1.64	16.03	1.09	2.22	0.14	0.54	2.87	14.62	99.24	12.70	0.09

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA107f	58.90	13.19	0.09	2.44	5.89	0.85	3.65	0.15	0.76	5.84	8.03	99.79	4.63	0.01
00DKA107g	51.90	12.57	0.17	2.48	10.58	0.75	3.34	0.14	0.65	5.08	11.74	99.40	8.46	0.02
00DKA107h	55.57	14.70	0.09	2.91	5.33	0.57	4.30	0.14	0.76	6.53	8.26	99.16	4.28	0.01
00DKA107i	54.36	13.52	0.11	2.65	7.67	0.66	3.78	0.14	0.73	5.96	9.85	99.43	6.14	0.01
00DKA107j	54.33	13.70	0.11	2.71	7.32	0.68	3.83	0.14	0.73	6.10	9.78	99.43	5.90	0.01
00DKA107k	55.70	13.42	0.10	2.59	6.81	0.77	3.70	0.14	0.74	6.02	9.41	99.41	5.80	0.04
00DKA111a	47.89	11.83	0.12	2.93	12.52	0.63	3.20	0.15	0.69	4.86	14.31	99.13	10.70	0.02
00DKA111b	46.27	10.51	0.13	2.66	15.01	0.71	2.71	0.16	0.65	4.00	15.81	98.63	12.70	0.02
00DKA111c	43.53	11.89	0.12	2.83	15.08	0.38	3.16	0.14	0.60	4.98	16.30	99.01	12.60	0.03
00DKA111d	44.53	10.14	0.13	3.08	16.06	0.56	3.11	0.15	0.57	4.22	16.93	99.47	13.70	0.02
00DKA113a	53.61	12.99	0.12	2.48	8.77	0.73	3.52	0.14	0.69	5.76	10.71	99.52	6.98	0.02
00DKA113b	53.84	12.73	0.11	2.47	9.07	0.72	3.44	0.14	0.70	5.47	10.88	99.56	7.15	0.01
00DKA114a	46.78	13.17	0.13	3.06	12.43	0.29	3.63	0.14	0.65	4.74	14.34	99.36	10.40	0.02
00DKA114b	51.43	15.53	0.10	3.30	6.70	0.27	4.40	0.14	0.73	6.19	10.12	98.90	5.47	0.18
00DKA114c	53.05	14.82	0.11	3.36	6.40	0.29	4.48	0.14	0.74	6.35	10.01	99.75	5.49	0.06
00DKA114d	51.45	13.86	0.11	3.18	8.45	0.30	4.14	0.15	0.73	5.62	11.26	99.23	7.12	0.07
00DKA114e	50.42	13.01	0.12	3.12	10.21	0.35	3.88	0.16	0.70	4.93	12.47	99.36	8.68	0.04
00DKA114f	54.04	15.11	0.09	3.37	5.21	0.22	4.69	0.14	0.78	6.66	9.03	99.34	4.46	0.06
00DKA114g	51.14	14.23	0.11	3.22	8.24	0.22	4.28	0.14	0.73	5.67	11.34	99.31	7.05	0.02
00DKA125a	40.44	10.27	0.12	7.39	10.87	0.09	3.49	0.12	0.53	4.92	21.50	99.73	14.40	0.06
00DKA125b	36.66	10.30	0.11	6.50	13.52	0.09	3.16	0.11	0.48	4.79	21.54	97.26	15.24	0.66
00DKA125c	39.10	12.21	0.10	6.16	10.26	0.13	3.76	0.11	0.55	6.06	20.93	99.37	12.40	0.02
00DKA125d	31.33	9.53	0.09	3.73	21.68	0.13	3.23	0.13	0.40	4.04	25.23	99.50	19.14	0.07
00DKA134a	56.34	13.81	0.09	2.71	5.55	0.80	3.88	0.14	0.75	6.32	9.63	100.02	4.51	0.02
00DKA134b	55.72	12.54	0.11	2.54	7.93	0.89	3.41	0.15	0.72	4.98	10.55	99.54	6.60	0.02
00DKA136a	45.87	11.10	0.13	2.77	13.73	0.65	3.00	0.14	0.60	4.35	16.61	98.96	11.90	0.02
00DKA136b	42.93	9.45	0.14	2.74	17.97	0.66	2.95	0.16	0.55	3.44	18.62	99.60	15.20	0.02
00DKA136c	40.81	11.18	0.12	2.92	16.07	0.35	3.63	0.15	0.55	5.14	18.47	99.39	13.50	0.03
00DKA136d	30.90	7.16	0.20	2.57	27.60	0.45	2.26	0.12	0.38	2.88	25.47	99.98	23.00	0.03
00DKA137a	55.75	13.32	0.11	2.50	6.51	0.84	3.63	0.14	0.73	5.68	10.43	99.65	5.24	0.01
00DKA137b	52.83	12.97	0.12	2.44	7.75	0.80	3.48	0.14	0.70	6.15	11.62	99.02	6.29	0.01
00DKA137c	52.54	10.71	0.17	2.12	12.16	1.00	2.61	0.14	0.64	3.94	13.54	99.59	10.00	0.01

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA138a	56.61	13.88	0.09	2.83	6.17	0.85	3.79	0.15	0.78	5.43	9.17	99.75	5.27	0.01
00DKA138b	52.63	11.91	0.13	2.74	10.58	0.89	3.06	0.16	0.71	4.46	12.36	99.63	9.23	0.02
00DKA140a	48.39	12.05	0.12	2.76	12.47	0.71	3.12	0.15	0.65	4.78	14.16	99.37	10.75	0.02
00DKA140b	42.40	9.97	0.14	2.76	17.74	0.69	2.97	0.15	0.54	4.24	17.92	99.49	15.11	0.07
00DKA140c	45.62	11.95	0.13	2.81	14.15	0.65	3.02	0.14	0.63	4.67	15.55	99.31	12.20	0.03
00DKA140d	42.28	10.46	0.13	2.86	17.20	0.59	3.17	0.14	0.55	4.54	17.72	99.66	14.61	0.03
00DKA140e	44.86	11.94	0.12	2.75	13.85	0.57	3.18	0.15	0.61	5.05	15.62	98.69	11.70	0.02
00DKA144a	55.35	14.38	0.09	3.18	5.57	0.69	3.98	0.15	0.79	6.01	9.55	99.71	5.03	0.04
00DKA144b	55.30	14.05	0.10	2.88	6.84	0.76	3.79	0.15	0.77	5.48	9.65	99.75	5.73	0.02
00DKA145a	40.73	11.94	0.12	2.56	14.62	0.47	3.16	0.13	0.56	5.26	19.05	98.60	15.50	0.03
00DKA145b	42.33	11.76	0.12	2.85	15.23	0.49	3.73	0.14	0.57	5.71	16.08	99.02	12.20	0.03
00DKA145c	43.92	9.69	0.13	2.58	17.51	0.84	2.92	0.15	0.54	3.69	17.14	99.11	14.10	0.03
00DKA145d	47.54	12.36	0.11	2.77	12.09	0.75	3.32	0.14	0.64	5.18	13.81	98.71	10.10	0.03
00DKA145e	41.40	10.15	0.14	2.71	18.12	0.70	3.08	0.15	0.53	4.34	18.03	99.35	14.60	0.04
00DKA145f	49.88	13.14	0.10	2.90	10.01	0.78	3.55	0.14	0.68	5.86	12.13	99.18	8.30	0.03
00DKA145g	40.83	9.90	0.14	2.70	19.13	0.76	2.87	0.15	0.52	3.99	18.47	99.45	15.30	0.03
00DKA145h	43.86	11.16	0.12	2.87	15.05	0.74	3.23	0.14	0.58	4.93	15.96	98.64	12.10	0.11
00DKA145i	44.56	10.80	0.13	2.77	15.57	0.82	3.20	0.15	0.57	4.78	16.04	99.39	12.50	0.07
00DKA145j	50.13	12.63	0.11	2.91	10.38	0.92	3.32	0.14	0.67	5.24	12.73	99.18	8.63	0.03
00DKA145k	45.14	10.33	0.14	2.70	15.87	0.86	2.95	0.15	0.57	4.32	16.42	99.45	12.80	0.03
00DKA145l	50.14	12.62	0.11	2.82	10.43	0.96	3.33	0.15	0.70	5.34	12.66	99.27	8.61	0.03
00DKA145m	49.48	11.58	0.13	2.61	11.92	1.07	2.97	0.15	0.67	4.55	13.46	98.60	9.69	0.11
00DKA145n	52.62	13.04	0.10	2.85	8.32	1.03	3.53	0.15	0.73	5.75	11.06	99.17	6.89	0.07
00DKA145o	50.51	10.95	0.14	2.65	12.10	1.11	2.66	0.16	0.67	4.32	13.47	98.74	9.86	0.09
00DKA145p	56.27	13.50	0.09	2.73	6.19	1.09	3.69	0.15	0.76	5.54	9.29	99.31	5.02	0.02
00DKA145q	52.07	12.11	0.12	2.68	10.09	1.07	3.14	0.15	0.69	4.86	12.00	98.99	8.22	0.02
00DKA146a	45.17	11.57	0.13	2.70	14.72	0.61	3.00	0.14	0.60	4.57	15.50	98.71	7.92	0.02
00DKA146b	46.50	12.64	0.12	2.84	12.49	0.56	3.46	0.14	0.64	5.45	14.07	98.90	11.10	0.02
00DKA146c	45.12	10.73	0.13	2.83	14.99	0.67	3.30	0.15	0.57	4.62	15.59	98.70	15.40	0.02
00DKA146d	50.70	12.37	0.11	2.82	10.64	0.82	3.36	0.16	0.68	5.04	12.30	98.99	10.40	0.03
00DKA146e	46.86	11.44	0.13	2.74	13.64	0.75	2.97	0.15	0.63	4.43	14.77	98.62	17.00	0.03
00DKA146f	49.94	13.32	0.11	3.01	9.55	0.73	3.74	0.15	0.69	5.92	11.94	99.10	7.13	0.03

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA146g	49.17	12.53	0.13	2.88	11.34	0.81	3.37	0.15	0.68	5.06	13.05	99.15	13.30	0.03
00DKA146h	55.35	11.93	0.11	2.51	8.85	1.13	3.10	0.15	0.72	4.72	10.56	99.13	10.70	0.02
00DKA146i	52.21	13.42	0.11	2.99	8.17	0.80	3.81	0.16	0.74	5.82	10.86	99.08	5.64	0.02
00DKA146j	53.53	12.49	0.12	2.80	9.08	0.95	3.29	0.15	0.71	4.89	11.19	99.21	6.56	0.02
00DKA146k	55.17	13.60	0.10	2.87	6.85	0.92	3.75	0.15	0.78	5.46	9.72	99.35	5.74	0.01
00DKA146l	50.92	12.71	0.13	2.85	10.29	0.79	3.42	0.15	0.69	5.32	11.63	98.89	3.76	0.01
00DKA146m	54.60	11.18	0.14	2.56	10.58	1.15	2.79	0.15	0.67	3.90	11.38	99.10	6.90	0.02
00DKA146n	54.18	14.01	0.10	2.95	7.03	0.77	3.94	0.15	0.74	6.27	9.21	99.35	2.04	0.01
00DKA146o	54.30	12.95	0.12	2.74	8.55	0.93	3.41	0.15	0.72	5.24	10.04	99.15	2.08	0.01
00DKA146p	55.90	14.50	0.08	2.82	5.38	0.88	4.07	0.14	0.77	6.52	8.48	99.56	9.68	0.01
00DKA146q	57.01	13.36	0.10	2.69	6.41	1.01	3.63	0.14	0.73	4.99	9.06	99.13	4.07	0.06
00DKA147a	46.85	11.22	0.13	2.65	14.22	0.77	2.93	0.14	0.60	4.25	14.94	98.70	11.50	0.02
00DKA147b	46.73	11.21	0.13	2.67	14.20	0.76	2.92	0.14	0.59	4.25	14.99	98.61	9.46	0.02
00DKA147c	48.43	12.69	0.11	2.95	11.53	0.62	3.50	0.15	0.65	5.25	13.35	99.21	13.60	0.02
00DKA147d	45.43	11.78	0.12	2.69	14.28	0.64	3.09	0.14	0.60	4.85	15.16	98.78	11.50	0.03
00DKA147e	41.52	9.64	0.14	2.73	18.96	0.65	2.90	0.15	0.52	4.01	18.36	99.58	15.00	0.04
00DKA147f	43.26	10.79	0.12	2.79	16.19	0.65	3.32	0.15	0.57	4.78	16.54	99.15	13.00	0.03
00DKA147g	45.68	11.15	0.13	2.61	14.69	0.79	2.89	0.14	0.60	4.39	15.54	98.59	11.90	0.04
00DKA147h	51.79	12.81	0.11	2.91	9.49	0.86	3.50	0.14	0.67	5.23	11.53	99.04	7.86	0.03
00DKA147i	46.42	11.33	0.13	2.75	14.17	0.80	2.89	0.14	0.60	4.37	14.99	98.60	11.30	0.15
00DKA147j	49.83	13.02	0.11	2.99	10.09	0.83	3.59	0.15	0.69	5.45	12.31	99.06	8.40	0.03
00DKA147k	52.34	12.11	0.11	2.63	10.24	1.03	3.22	0.15	0.69	4.80	11.75	99.07	8.34	0.05
00DKA147l	50.76	13.61	0.09	2.95	7.67	0.76	3.81	0.15	0.72	6.19	10.42	99.13	5.98	0.47
00DKA147m	49.90	11.79	0.13	2.75	11.67	0.97	2.96	0.15	0.68	4.67	13.14	98.83	9.41	0.05
00DKA147n	55.38	13.91	0.09	2.84	6.02	0.94	3.90	0.14	0.77	6.11	9.13	99.22	4.77	0.02
00DKA147o	51.38	12.52	0.12	2.73	9.99	0.96	3.29	0.16	0.73	5.20	11.98	99.06	8.02	0.03
00DKA147p	51.75	12.89	0.11	2.76	9.59	0.90	3.44	0.16	0.72	5.28	11.80	99.39	7.71	0.03
00DKA147q	56.02	12.61	0.11	2.58	8.06	1.13	3.23	0.15	0.74	4.68	10.27	99.58	6.41	0.06
00DKA147r	54.58	14.00	0.09	2.82	6.56	0.85	3.89	0.14	0.76	6.11	9.77	99.56	5.06	0.04
00DKA147s	51.32	11.39	0.15	2.40	12.12	1.13	2.69	0.16	0.71	3.84	13.12	99.03	9.52	0.02
00DKA148a	50.59	14.08	0.09	3.03	8.16	0.41	4.08	0.15	0.73	6.13	11.83	99.28	7.83	0.02
00DKA148b	44.76	12.38	0.12	2.83	13.86	0.42	3.32	0.15	0.62	4.96	15.42	98.83	11.70	0.03
00DKA148c	49.74	13.32	0.10	2.97	9.92	0.50	3.79	0.15	0.70	5.52	12.37	99.07	8.54	0.03

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA148d	42.34	10.95	0.12	2.87	16.67	0.48	3.47	0.14	0.56	4.11	17.06	98.78	13.90	0.03
00DKA148e	44.95	12.11	0.11	2.73	12.72	0.49	3.33	0.14	0.62	4.91	16.73	98.84	11.20	0.03
00DKA148f	48.56	13.53	0.09	2.92	9.55	0.47	3.87	0.14	0.68	5.86	11.76	97.42	7.31	0.52
00DKA148g	37.70	9.51	0.15	2.71	21.43	0.45	3.03	0.15	0.48	3.05	20.78	99.44	18.00	0.04
00DKA148h	40.41	11.68	0.11	2.94	16.44	0.27	3.87	0.14	0.54	5.44	17.30	99.14	14.00	0.03
00DKA148i	42.05	10.77	0.11	2.90	16.70	0.49	3.48	0.15	0.55	4.74	17.18	99.13	14.50	0.06
00DKA148j	41.42	9.60	0.12	2.77	18.40	0.62	3.07	0.14	0.51	3.89	17.96	98.50	15.20	0.37
00DKA148k	45.62	11.96	0.11	2.84	13.69	0.57	3.21	0.15	0.63	4.92	15.05	98.74	11.60	0.03
00DKA148l	39.70	9.14	0.14	2.81	20.19	0.61	2.80	0.15	0.49	3.79	19.55	99.37	17.30	0.05
00DKA148m	46.64	10.81	0.12	2.58	14.56	0.83	2.81	0.15	0.59	3.75	14.98	97.83	12.20	0.32
00DKA148n	45.57	11.71	0.11	2.98	13.25	0.70	3.05	0.14	0.61	4.92	14.44	97.47	10.40	0.70
00DKA149a	47.58	13.57	0.12	3.38	10.84	0.21	3.97	0.15	0.67	5.43	13.54	99.45	9.32	0.02
00DKA149b	49.85	13.58	0.10	3.23	9.62	0.27	4.01	0.16	0.70	5.39	12.36	99.27	8.05	0.10
00DKA149c	40.49	10.26	0.16	3.29	18.47	0.30	3.39	0.15	0.52	3.50	18.86	99.40	15.80	0.06
00DKA149d	48.04	13.38	0.11	3.20	10.38	0.32	3.91	0.15	0.68	5.76	13.04	98.96	8.85	0.07
00DKA149e	46.31	11.50	0.13	2.95	14.10	0.49	3.18	0.17	0.63	3.95	15.31	98.73	11.80	0.16
00DKA149f	51.56	14.02	0.10	3.29	8.19	0.38	4.21	0.15	0.73	5.83	11.22	99.67	7.07	0.04
00DKA149g	45.15	12.10	0.12	3.13	13.81	0.33	3.42	0.15	0.63	4.70	15.49	99.05	11.90	0.03
00DKA149h	49.61	13.47	0.10	3.27	9.13	0.39	4.03	0.15	0.69	5.65	12.47	98.96	7.83	0.15
00DKA150a	37.17	8.86	0.13	2.51	22.29	0.54	2.76	0.15	0.46	3.77	20.86	99.49	18.40	0.03
00DKA150b	47.40	12.41	0.10	2.78	12.61	0.60	3.36	0.14	0.66	5.26	14.10	99.43	10.60	0.02
00DKA150c	43.48	10.77	0.11	2.90	16.18	0.56	3.35	0.14	0.55	4.84	16.61	99.48	13.60	0.03
00DKA150d	41.72	10.70	0.12	2.85	17.18	0.51	3.36	0.14	0.54	4.83	17.43	99.38	14.50	0.03
00DKA150e	44.08	12.58	0.10	2.90	13.92	0.49	3.36	0.14	0.62	5.33	15.46	98.99	11.80	0.03
00DKA150f	40.48	9.69	0.12	2.66	19.46	0.58	3.00	0.15	0.51	4.12	18.84	99.61	16.20	0.02
00DKA151a	48.26	14.71	0.08	3.50	8.56	0.11	4.42	0.13	0.69	6.79	12.59	99.85	7.38	0.01
00DKA151b	40.92	10.95	0.10	3.40	16.87	0.14	3.82	0.15	0.54	3.68	18.29	98.85	14.50	0.02
00DKA151c	45.04	13.78	0.09	3.44	11.28	0.13	4.01	0.13	0.63	6.10	14.83	99.45	9.83	0.01
00DKA151d	42.21	11.14	0.10	3.20	16.75	0.14	3.81	0.15	0.56	3.57	17.75	99.38	14.10	0.02
00DKA151e	42.81	13.22	0.09	3.46	13.55	0.12	3.80	0.14	0.60	5.62	15.90	99.33	11.80	0.02
00DKA151f	39.91	11.35	0.10	3.45	17.78	0.17	3.76	0.13	0.52	3.66	18.73	99.57	15.10	0.02
00DKA151g	44.66	13.98	0.09	3.62	11.53	0.13	4.08	0.13	0.62	6.13	14.63	99.60	10.30	0.01
00DKA151h	41.70	12.01	0.10	3.61	15.22	0.14	4.06	0.14	0.55	4.54	17.01	99.09	13.20	0.02

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA151i	42.13	13.46	0.09	3.09	13.89	0.13	3.80	0.14	0.59	5.72	15.82	98.85	11.70	0.02
00DKA151j	42.06	11.58	0.10	3.30	15.75	0.16	3.93	0.14	0.56	4.53	17.12	99.22	13.50	0.02
00DKA151k	47.46	13.81	0.08	3.29	10.20	0.12	4.17	0.14	0.67	6.03	13.07	99.04	8.75	0.02
00DKA151l	40.51	10.78	0.11	3.24	17.69	0.14	3.72	0.17	0.52	3.76	18.58	99.24	15.20	0.02
00DKA151m	46.19	14.51	0.08	3.46	10.16	0.16	4.29	0.15	0.66	6.24	13.55	99.45	8.83	0.02
00DKA151n	43.99	12.13	0.10	3.28	14.37	0.15	3.56	0.16	0.61	4.53	16.10	98.99	12.50	0.02
00DKA151o	45.58	13.88	0.09	3.55	10.94	0.15	4.10	0.15	0.66	6.11	14.02	99.21	9.89	0.02
00DKA151p	41.35	12.54	0.10	3.71	14.50	0.15	3.60	0.15	0.58	5.06	17.05	98.79	13.10	0.02
00DKA151q	41.77	11.56	0.09	3.51	15.04	0.19	3.97	0.14	0.56	5.35	16.75	98.93	13.20	0.03
00DKA151r	42.30	9.60	0.10	3.27	17.82	0.34	3.38	0.14	0.53	3.35	18.25	99.09	15.40	0.06
00DKA151s	44.46	13.55	0.09	3.54	11.54	0.17	4.03	0.13	0.63	6.16	14.41	98.71	10.40	0.06
00DKA151t	38.23	11.44	0.10	3.29	17.80	0.20	3.89	0.13	0.50	4.60	18.89	99.07	15.20	0.05
00DKA151u	38.03	9.96	0.10	3.11	19.63	0.21	3.50	0.13	0.48	4.21	19.73	99.09	16.90	0.04
00DKA151v	33.98	9.36	0.10	3.17	20.64	0.17	3.15	0.13	0.43	3.83	20.41	95.37	16.70	0.91
00DKA151w	39.68	11.66	0.10	4.23	15.04	0.18	3.90	0.13	0.53	5.30	17.24	97.99	13.10	0.43
00DKA151x	39.35	11.66	0.11	4.87	15.07	0.20	3.86	0.12	0.53	5.04	17.85	98.66	13.70	0.38
00DKA152a	46.84	12.81	0.10	3.03	12.05	0.15	3.81	0.13	0.64	5.46	13.90	98.92	9.95	0.01
00DKA152b	46.61	13.06	0.10	3.11	12.12	0.14	3.83	0.13	0.63	5.58	14.19	99.49	10.10	0.01
00DKA152c	46.32	12.80	0.10	3.11	12.28	0.12	3.73	0.13	0.62	5.59	14.57	99.38	10.30	n.d.
00DKA152d	49.95	12.74	0.10	3.15	10.45	0.20	3.84	0.14	0.66	5.49	12.69	99.40	9.05	n.d.
00DKA152e	51.10	12.01	0.12	3.75	10.06	0.32	3.71	0.14	0.64	4.79	12.97	99.60	9.62	0.02
00DKA152f	48.08	12.73	0.11	4.06	10.71	0.29	3.81	0.14	0.64	4.86	14.03	99.46	10.80	0.06
00DKA152g	44.77	9.59	0.12	3.85	15.62	0.46	3.23	0.14	0.49	4.22	16.92	99.41	14.60	0.20
00DKA152h	44.62	9.75	0.13	3.97	15.17	0.46	3.23	0.15	0.50	4.36	17.08	99.42	14.40	0.14
00-DKA-154a	36.65	11.28	0.09	5.92	16.26	0.16	3.68	0.14	0.49	5.04	19.98	99.69	16.90	0.02
00-DKA-154b	39.47	13.49	0.08	3.94	14.52	0.17	3.78	0.15	0.55	5.87	17.04	99.07	13.40	0.02
00-DKA-154c	45.85	15.25	0.08	3.95	9.46	0.15	4.58	0.13	0.65	6.79	12.88	99.78	8.84	0.01
00-DKA-154d	42.74	14.69	0.08	3.92	11.70	0.18	4.29	0.13	0.61	6.40	14.64	99.38	10.70	0.02
00-DKA-154e	39.77	14.68	0.09	4.97	9.91	0.17	4.49	0.15	0.62	6.49	14.24	99.57	10.40	0.02
00-DKA-154f	43.37	13.16	0.10	4.68	14.38	0.17	3.80	0.14	0.55	5.22	17.54	99.12	14.00	0.02
00-DKA-154g	41.26	13.99	0.10	5.78	10.83	0.21	4.25	0.13	0.59	6.41	15.92	99.47	12.40	0.02
00-DKA-154h	40.32	13.76	0.10	5.68	11.71	0.17	4.18	0.13	0.57	6.11	16.62	99.35	12.90	0.02
00-DKA-154i	39.32	13.30	0.10	4.80	13.86	0.19	3.85	0.13	0.54	5.68	17.41	99.18	13.60	0.04

Appendix 4: major and minor element data for composite samples (see Appendix 2 for sample locations and descriptions; all data in weight %, double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00-DKA-154j	36.73	12.32	0.09	4.11	16.84	0.22	4.08	0.12	0.49	5.37	18.87	99.23	15.30	0.05
00-DKA-154k	39.09	13.40	0.10	5.21	13.20	0.19	3.95	0.13	0.54	6.13	17.37	99.32	13.60	0.03
00-DKA-154l	35.73	11.49	0.10	5.96	16.27	0.24	3.77	0.12	0.48	5.16	20.20	99.52	16.90	0.05
00-DKA-154m	36.42	12.19	0.10	7.45	12.70	0.23	3.64	0.13	0.50	5.98	19.28	98.64	15.60	0.24
00-DKA-154n	29.69	9.92	0.09	5.36	22.61	0.23	3.32	0.12	0.37	3.35	24.40	99.44	21.80	0.05
00-DKA-154o	31.99	10.53	0.09	4.67	21.16	0.27	3.46	0.13	0.40	4.21	22.51	99.41	19.60	0.09
00-DKA-154p	17.19	5.54	0.10	4.75	35.02	0.17	1.76	0.10	0.20	2.25	32.41	99.47	31.70	0.25
00-DKA-154q	36.69	12.04	0.08	4.88	16.86	0.28	3.85	0.12	0.48	4.55	19.22	99.05	16.00	0.18
00-DKA-154r	21.15	7.24	0.10	3.94	31.84	0.24	2.23	0.08	0.26	2.94	29.11	99.13	28.00	0.37
00-DKA-154s	38.26	13.24	0.08	3.63	15.78	0.31	4.25	0.12	0.51	5.29	17.40	98.89	13.60	0.09
00-DKA-154t	16.10	5.37	0.10	2.48	38.64	0.18	1.68	0.07	0.18	2.07	33.03	99.89	32.00	0.12
00-DKA-154u	34.35	10.92	0.09	3.96	20.08	0.26	3.53	0.11	0.44	4.61	20.91	99.25	17.90	0.09
00-DKA-154v	28.58	8.95	0.09	3.55	25.84	0.29	2.77	0.10	0.36	3.50	24.59	98.62	22.10	0.39
00-DKA-154w	33.05	10.45	0.09	4.74	20.31	0.28	3.35	0.15	0.42	4.51	21.61	98.96	19.00	0.21
00-DKA-154x	16.37	4.29	0.10	3.71	37.95	0.14	1.51	0.08	0.19	1.75	33.61	99.68	32.40	0.16
00-DKA-154y	37.85	11.40	0.11	7.44	13.17	0.23	3.34	0.12	0.52	5.11	19.47	98.77	16.10	0.20
00-DKA-154z	38.77	12.02	0.12	7.90	11.74	0.23	3.57	0.13	0.54	5.35	18.69	99.06	15.40	0.20
00-DKA-154aa	39.34	12.65	0.11	6.51	12.34	0.23	3.65	0.13	0.55	5.69	17.80	99.01	14.00	0.13
00-DKA-154ab	38.19	10.92	0.12	7.56	12.52	0.24	3.27	0.12	0.52	4.98	18.59	97.02	14.60	1.00
00-DKA-154ac	41.82	12.53	0.11	6.61	10.53	0.27	3.76	0.11	0.58	6.04	16.28	98.64	12.10	0.47
detection limits:	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	n/a	0.03	0.01

APPENDIX 5

Major and minor element data for bed samples (modified after Armstrong 2001).

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
00DKA001a	51.89	14.94	0.09	4.92	4.29	0.18	4.84	0.14	0.75	5.06	12.04	99.15	5.47	0.40
00DKA001b	53.69	15.95	0.09	4.66	3.17	0.19	5.04	0.14	0.80	7.26	9.28	100.26	4.01	n.d.
00DKA001c	48.47	14.56	0.11	4.43	7.68	0.22	4.39	0.14	0.70	6.70	12.66	100.06	7.65	0.01
00DKA001d	52.30	15.19	0.09	3.78	5.87	0.22	4.66	0.14	0.75	6.73	10.48	100.21	5.37	0.01
00DKA001e	52.48	15.75	0.09	3.82	5.26	0.23	4.80	0.14	0.78	6.40	10.39	100.13	4.79	0.02
00DKA001f	48.40	14.52	0.12	3.59	8.64	0.26	4.35	0.15	0.71	5.73	13.02	99.49	7.58	0.02
00DKA001g	43.35	11.71	0.09	2.90	13.02	0.43	3.06	0.14	0.60	3.61	14.64	93.55	6.74	2.76
00DKA001h	50.35	13.98	0.09	3.25	8.49	0.41	4.02	0.15	0.70	5.16	12.39	99.00	6.68	0.33
00DKA001i	42.37	11.49	0.12	3.26	15.09	0.35	3.67	0.16	0.58	5.20	17.14	99.43	12.40	0.07
00DKA001j	51.38	13.44	0.10	3.27	8.96	0.58	3.84	0.14	0.72	5.39	11.93	99.74	7.55	0.02
00DKA001k	43.46	13.42	0.10	3.15	13.11	0.28	3.71	0.14	0.61	6.14	15.08	99.21	10.70	0.03
00DKA001l	40.48	10.35	0.12	3.11	17.96	0.50	3.21	0.15	0.57	4.48	18.49	99.41	14.90	0.03
00DKA001m	46.42	12.80	0.10	3.01	12.18	0.44	3.58	0.14	0.64	5.80	14.21	99.31	10.10	0.03
00DKA001n	38.24	9.82	0.14	3.27	19.88	0.45	3.03	0.15	0.51	3.82	20.14	99.46	16.40	0.04
00DKA001o	55.77	12.39	0.11	3.08	7.76	0.91	3.45	0.15	0.71	4.98	10.47	99.79	6.78	0.03
00DKA001p	47.36	10.37	0.16	3.29	14.88	0.86	2.48	0.15	0.61	3.38	16.04	99.59	12.90	0.03
00DKA001q	50.03	11.74	0.14	3.30	11.99	0.82	3.01	0.14	0.65	3.78	13.96	99.57	10.50	0.02
00DKA001r	56.81	13.33	0.09	3.03	6.31	0.87	3.80	0.15	0.75	5.45	9.27	99.87	5.38	0.02
00DKA001s	55.73	12.73	0.10	2.91	7.56	0.87	3.52	0.14	0.67	5.47	10.10	99.81	6.35	0.02
00DKA001t	52.52	14.35	0.10	3.16	6.57	0.56	4.19	0.14	0.73	7.53	10.01	99.86	5.50	0.02
00DKA001u	53.97	15.29	0.08	3.20	4.50	0.45	4.61	0.14	0.77	8.17	8.75	99.92	3.55	0.02
00DKA001v	53.11	13.57	0.13	2.79	8.28	0.69	3.83	0.14	0.73	5.31	10.84	99.41	6.70	0.02
00DKA001w	56.10	16.30	0.06	3.37	2.39	0.38	4.98	0.13	0.81	7.52	7.99	100.03	1.94	n.d.
00DKA001x	59.31	14.95	0.06	2.96	2.52	0.75	4.43	0.15	0.81	7.26	6.74	99.94	1.97	n.d.
00DKA001y	54.08	10.04	0.15	2.10	11.67	0.95	2.45	0.14	0.58	4.93	12.35	99.42	9.34	0.02
00DKA001z	54.11	16.18	0.09	3.81	3.92	0.50	4.81	0.17	0.81	6.10	9.31	99.81	3.76	0.08
00DKA001aa	55.02	13.94	0.12	3.78	5.57	0.78	3.91	0.19	0.74	5.54	9.82	99.43	5.69	0.07
00DKA002a	52.02	9.89	0.15	2.50	14.14	1.11	2.11	0.16	0.62	3.43	14.31	100.42	11.70	0.04
00DKA002b	49.24	13.42	0.11	3.23	10.26	0.61	3.47	0.16	0.69	6.02	13.37	100.57	8.61	0.02
00DKA002c	42.01	8.19	0.17	2.63	20.67	0.95	2.28	0.16	0.50	2.67	19.66	99.89	17.00	0.03
00DKA002d	46.52	8.18	0.15	2.42	18.34	1.06	2.29	0.18	0.54	2.60	17.71	99.99	14.90	0.03
00DKA002e	45.42	11.98	0.12	2.74	13.91	0.64	3.08	0.14	0.62	4.98	15.88	99.51	11.50	0.03
00DKA002f	46.72	12.31	0.11	2.93	12.36	0.65	3.16	0.14	0.65	5.46	15.48	99.96	10.30	0.03

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA002g	45.88	8.65	0.17	2.94	18.43	0.98	2.16	0.17	0.61	3.26	17.94	101.19	15.20	0.02
00DKA002h	38.54	6.90	0.19	2.45	24.47	0.80	1.84	0.14	0.41	2.70	22.18	100.63	19.60	0.03
00DKA002i	44.66	7.71	0.18	2.29	20.52	1.00	2.03	0.15	0.49	2.15	18.87	100.04	16.70	0.03
00DKA002j	40.38	9.07	0.15	2.77	19.81	0.68	2.67	0.15	0.52	3.90	19.75	99.87	16.30	0.03
00DKA002k	44.30	13.46	0.10	2.94	11.64	0.36	3.72	0.14	0.62	5.98	16.22	99.48	9.57	0.02
00DKA002l	52.34	13.97	0.08	3.04	6.96	0.67	4.00	0.15	0.73	6.51	11.32	99.78	5.83	0.02
00DKA002m	46.06	8.38	0.15	2.58	17.78	0.99	2.47	0.17	0.54	3.21	17.50	99.82	14.70	0.04
00DKA002n	43.66	11.12	0.12	2.91	15.21	0.62	3.39	0.17	0.59	5.14	16.15	99.09	12.60	0.03
00DKA002o	51.88	14.48	0.11	3.25	7.31	0.27	4.15	0.14	0.75	6.03	11.95	100.32	8.08	0.02
00DKA002p	48.70	12.84	0.09	2.87	9.36	0.63	3.60	0.16	0.68	5.80	14.83	99.56	11.90	0.03
00DKA002q	36.65	6.80	0.17	2.29	26.20	0.77	1.94	0.18	0.44	2.03	23.10	100.58	20.80	0.03
00DKA003a	36.20	7.21	0.15	2.69	24.86	0.52	2.26	0.19	0.49	2.36	22.85	99.80	20.30	0.04
00DKA003b	39.27	11.32	0.05	2.35	12.98	0.27	3.07	0.11	0.53	5.43	12.67	88.07	3.49	4.65
00DKA003c	47.34	14.39	0.09	3.36	8.74	0.13	4.17	0.13	0.67	6.83	11.71	97.56	6.19	0.99
00DKA003d	53.31	10.59	0.12	2.78	12.65	0.81	2.76	0.15	0.65	2.85	13.44	100.12	10.60	0.02
00DKA003e	51.87	15.14	0.09	3.67	6.66	0.20	4.46	0.14	0.74	6.79	10.37	100.14	5.81	0.02
00DKA003f	53.02	14.38	0.09	3.66	7.50	0.26	4.35	0.14	0.74	4.09	11.25	99.47	6.66	0.01
00DKA003g	52.04	14.07	0.10	3.69	7.68	0.24	4.24	0.15	0.73	5.62	11.12	99.67	6.83	0.02
00DKA003h	41.08	7.58	0.13	2.51	22.16	0.60	2.36	0.18	0.52	2.19	20.56	99.88	18.00	0.02
00DKA003i	52.06	14.72	0.10	3.59	7.66	0.19	4.23	0.14	0.74	6.49	10.82	100.75	6.59	0.01
00DKA003j	47.29	10.48	0.18	3.80	21.83	0.43	3.19	0.21	0.61	3.32	9.33	100.68	16.30	0.02
00DKA004a	49.37	12.54	0.13	3.24	12.56	0.36	3.30	0.14	0.68	3.52	14.38	100.22	10.70	0.03
00DKA004b	45.86	13.81	0.12	3.45	11.42	0.17	3.95	0.13	0.66	5.80	14.00	99.38	9.91	0.02
00DKA004c	56.11	15.82	0.08	3.57	3.30	0.28	4.90	0.14	0.82	7.28	7.81	100.10	2.97	n.d.
00DKA004d	46.77	10.82	0.13	3.02	14.62	0.54	3.01	0.15	0.60	3.03	15.78	98.46	12.60	0.02
00DKA004e	50.39	14.85	0.09	3.39	7.79	0.16	4.43	0.14	0.72	6.61	11.16	99.72	6.61	0.01
00DKA004f	54.73	14.88	0.09	3.39	5.63	0.28	4.58	0.14	0.79	6.38	9.14	100.03	4.96	n.d.
00DKA004g	48.82	12.53	0.12	3.51	11.70	0.31	3.65	0.16	0.68	3.85	14.30	99.62	10.70	0.01
00DKA004h	51.81	15.04	0.09	3.60	6.53	0.15	4.57	0.14	0.74	7.01	10.32	100.00	5.85	n.d.
00DKA004i	48.83	13.25	0.09	2.94	11.79	0.26	3.81	0.16	0.72	3.70	13.72	99.26	9.75	0.02
00DKA004k	55.28	14.78	0.08	3.29	5.40	0.26	4.59	0.14	0.78	6.31	9.14	100.06	4.83	0.01
00DKA004l	46.60	14.38	0.11	3.67	10.02	0.14	4.24	0.14	0.67	6.21	13.47	99.65	9.20	0.01
00DKA004m	37.58	10.03	0.15	4.68	19.25	0.16	3.28	0.15	0.49	2.87	21.10	99.76	17.90	0.02

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA004n	52.05	15.40	0.10	4.26	4.96	0.11	4.85	0.14	0.77	6.45	10.13	99.22	5.24	0.01
00DKA005a	37.23	10.73	0.12	2.64	19.64	0.29	3.51	0.14	0.49	4.83	19.52	99.15	16.00	0.03
00DKA005b	38.22	8.78	0.16	2.43	22.58	0.55	2.65	0.13	0.46	2.81	21.05	99.82	18.40	0.02
00DKA005c	45.39	12.91	0.10	2.62	13.63	0.42	3.46	0.16	0.64	4.84	15.14	99.32	11.10	0.02
00DKA005d	49.86	14.46	0.08	3.03	8.57	0.39	4.18	0.14	0.71	6.43	11.51	99.37	7.30	0.02
00DKA006a	51.32	14.22	0.10	3.91	7.21	0.10	4.49	0.14	0.72	6.40	11.21	99.81	6.99	0.01
00DKA006b	52.65	14.20	0.10	4.03	7.67	0.11	4.52	0.14	0.73	3.91	11.62	99.67	7.52	0.01
00DKA006c	51.36	11.29	0.12	3.65	11.38	0.20	3.59	0.16	0.71	3.12	13.90	99.49	10.70	0.01
00DKA006d	54.56	15.43	0.09	3.88	4.34	0.12	4.90	0.14	0.78	7.03	8.96	100.23	4.41	n.d.
00DKA006e	48.98	14.75	0.11	4.13	7.48	0.13	4.48	0.14	0.70	6.97	11.90	99.77	7.43	0.01
00DKA006f	48.57	15.26	0.11	4.05	7.28	0.13	4.59	0.13	0.70	7.06	11.97	99.85	7.34	0.01
00DKA007e	25.57	3.52	0.29	1.48	35.72	0.58	0.95	0.14	0.21	2.45	29.55	100.46	28.10	0.02
00DKA007f	57.65	16.72	0.07	3.31	2.38	0.54	4.97	0.15	0.86	6.54	7.01	100.21	2.08	0.01
00DKA007i	58.65	15.88	0.06	3.14	2.21	0.59	4.64	0.14	0.83	7.50	6.62	100.26	1.77	0.01
00DKA007m	57.09	18.02	0.06	3.64	1.91	0.35	5.38	0.14	0.87	5.68	6.98	100.12	1.77	0.01
00DKA007o	63.30	9.75	0.11	1.57	8.72	1.30	2.40	0.13	0.60	2.80	9.14	99.82	6.90	0.02
00DKA007p	58.05	10.23	0.13	1.93	10.25	1.13	2.56	0.15	0.65	3.42	10.69	99.19	8.32	0.01
00DKA007r	59.31	12.94	0.10	2.44	7.03	0.89	3.47	0.14	0.73	3.82	9.04	99.93	6.00	0.01
00DKA007s	55.45	15.91	0.08	3.09	3.59	0.45	4.79	0.14	0.81	8.11	7.68	100.09	2.95	0.01
00DKA007u	52.48	7.76	0.18	1.75	16.42	1.24	1.90	0.14	0.50	2.36	15.10	99.83	13.40	0.01
00DKA007v	55.70	14.56	0.09	2.84	5.58	0.66	4.14	0.15	0.79	6.85	8.55	99.91	4.69	0.01
00DKA007w	58.68	13.72	0.09	2.65	5.17	0.83	3.82	0.16	0.80	6.08	8.00	99.98	4.23	0.01
00DKA007x	61.57	11.87	0.10	2.21	6.68	1.19	3.02	0.16	0.73	3.53	8.46	99.50	5.52	0.01
00DKA007y	55.14	14.39	0.09	2.77	6.12	0.65	4.06	0.14	0.76	6.84	9.23	100.21	4.92	0.01
00DKA007z	57.71	14.13	0.08	2.76	5.10	0.76	3.99	0.15	0.79	6.15	8.18	99.82	4.16	0.01
00DKA008a	52.24	15.16	0.08	3.61	6.00	0.14	4.65	0.14	0.76	6.65	9.93	99.36	5.30	0.01
00DKA008b	46.33	13.40	0.11	3.46	11.99	0.13	3.82	0.15	0.65	4.74	14.68	99.46	10.60	0.02
00DKA008c	49.32	14.79	0.10	3.87	7.73	0.12	4.42	0.13	0.72	6.77	11.91	99.88	7.32	0.01
00DKA008d	46.95	14.55	0.10	3.56	9.89	0.11	4.24	0.13	0.66	6.08	13.35	99.61	8.83	0.01
00DKA008e	50.05	14.30	0.09	3.57	8.33	0.12	4.30	0.14	0.71	6.28	12.07	99.95	7.73	0.01
00DKA008f	51.11	14.94	0.10	4.14	6.01	0.11	4.58	0.14	0.74	6.91	11.17	99.95	6.20	0.01
00DKA008g	54.40	16.17	0.08	3.94	3.60	0.13	4.97	0.14	0.79	7.29	8.84	100.34	3.77	n.d.

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA008h	50.59	15.15	0.09	3.94	6.73	0.11	4.54	0.14	0.73	6.79	11.26	100.07	6.55	0.01
00DKA008i	44.29	9.65	0.14	3.82	16.68	0.30	3.12	0.14	0.55	3.05	18.20	99.93	15.10	0.01
00DKA008j	55.40	15.70	0.08	3.90	4.80	0.12	4.84	0.14	0.81	4.46	9.81	100.06	4.71	n.d.
00DKA008k	56.69	16.28	0.08	3.92	3.51	0.12	5.08	0.14	0.82	4.68	8.83	100.16	3.68	n.d.
00DKA010a	40.09	8.62	0.14	2.85	21.13	0.62	2.52	0.14	0.50	2.92	20.42	99.95	17.80	0.02
00DKA010b	42.14	11.72	0.10	2.92	15.52	0.33	3.74	0.14	0.55	5.33	16.86	99.35	13.10	0.02
00DKA010c	41.44	11.57	0.10	2.89	15.96	0.30	3.70	0.16	0.56	5.41	17.17	99.27	13.40	0.03
00DKA010d	29.72	5.76	0.17	2.44	30.57	0.47	1.76	0.15	0.34	1.80	27.01	100.18	24.70	0.03
00DKA010e	43.69	13.72	0.09	2.91	12.93	0.19	3.77	0.14	0.61	6.26	15.15	99.48	10.90	0.02
00DKA010f	40.97	6.85	0.15	2.11	23.43	0.77	2.02	0.15	0.46	1.97	21.13	100.02	19.20	0.03
00DKA011a	46.60	8.49	0.16	3.32	16.68	0.88	2.51	0.18	0.67	3.15	17.19	99.83	15.00	0.02
00DKA011b	48.62	8.15	0.16	2.88	16.46	0.96	2.40	0.15	0.58	2.82	16.59	99.76	14.60	0.01
00DKA011c	46.30	8.36	0.15	2.64	17.84	0.88	2.38	0.16	0.57	3.18	17.39	99.86	15.10	0.02
00DKA011d	44.06	12.12	0.11	2.92	14.59	0.41	3.23	0.16	0.65	4.80	16.11	99.17	12.60	0.02
00DKA011f	50.47	8.66	0.15	2.84	15.09	0.94	2.40	0.14	0.53	3.07	15.53	99.82	13.30	0.01
00DKA011g	40.74	9.31	0.15	3.04	19.80	0.60	2.73	0.14	0.49	3.14	19.73	99.87	16.90	0.02
00DKA012a	53.41	14.24	0.10	2.52	7.29	0.60	3.88	0.14	0.73	6.60	10.18	99.67	5.94	0.01
00DKA013a	57.77	15.42	0.07	2.83	3.26	0.65	4.36	0.14	0.80	7.33	7.36	99.99	2.52	0.01
00DKA013b	52.55	7.70	0.16	1.55	16.71	1.17	1.98	0.12	0.45	2.26	15.30	99.97	13.30	0.01
00DKA013c	56.06	14.44	0.08	2.76	5.61	0.64	4.07	0.14	0.75	6.79	8.79	100.14	4.49	0.01
00DKA014a	37.36	7.67	0.23	2.73	23.91	0.50	2.42	0.15	0.40	2.17	22.39	99.93	20.10	0.03
00DKA014b	48.52	14.13	0.13	3.32	9.80	0.22	4.06	0.15	0.68	5.81	12.80	99.61	8.67	0.02
00DKA014c	45.16	11.95	0.14	3.10	14.42	0.35	3.23	0.15	0.61	3.54	16.00	98.66	12.40	0.05
00DKA014d	51.73	14.29	0.09	3.17	7.73	0.29	4.24	0.14	0.72	5.90	10.53	98.84	5.38	0.74
00DKA014f	52.69	15.71	0.11	3.48	5.32	0.16	4.87	0.14	0.78	7.19	9.53	99.98	4.78	0.02
00DKA014g	46.48	12.71	0.13	2.97	13.54	0.28	3.60	0.15	0.65	3.47	15.24	99.22	11.80	0.03
00DKA014h	45.92	9.75	0.17	3.07	16.26	0.56	3.12	0.15	0.51	2.70	17.03	99.22	14.20	0.04
00DKA014i	53.06	15.24	0.10	3.52	5.47	0.20	4.67	0.14	0.77	6.83	9.56	99.56	4.87	0.01
00DKA014j	52.31	15.32	0.10	3.39	6.60	0.14	4.65	0.15	0.76	6.72	10.28	100.42	5.70	0.01
00DKA014k	53.07	15.69	0.09	3.41	5.29	0.12	4.79	0.14	0.79	7.13	9.38	99.89	4.69	0.01
00DKA014l	49.39	11.45	0.14	2.85	13.79	0.48	3.15	0.15	0.69	3.01	14.85	99.93	11.70	0.01
00DKA014m	52.30	15.44	0.10	3.38	5.81	0.15	4.69	0.14	0.77	7.10	10.00	99.86	5.14	0.01

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA014n	51.63	15.48	0.09	3.23	6.79	0.13	4.60	0.14	0.75	6.71	10.53	100.08	5.88	0.01
00DKA015a	49.52	12.62	0.10	2.46	12.15	0.27	3.59	0.15	0.67	4.06	14.02	99.61	10.30	0.02
00DKA016a	52.74	15.00	0.09	3.11	6.39	0.11	4.53	0.14	0.76	6.62	10.38	99.86	5.82	0.01
00DKA017a	52.10	15.34	0.09	3.24	6.34	0.13	4.61	0.14	0.76	6.78	10.40	99.91	5.68	0.01
00DKA017b	49.70	14.73	0.10	3.31	8.07	0.13	4.36	0.14	0.73	6.57	11.73	99.56	7.42	0.01
00DKA017c	53.14	14.57	0.09	2.94	6.36	0.18	4.38	0.14	0.75	6.24	11.07	99.86	6.79	0.01
00DKA017d	54.15	15.36	0.08	3.15	5.38	0.15	4.70	0.14	0.77	6.53	9.91	100.32	4.94	n.d.
00DKA017e	54.82	16.07	0.08	2.86	4.18	0.14	4.80	0.14	0.80	7.59	8.80	100.30	3.43	0.01
00DKA018a	55.86	16.68	0.08	3.37	2.81	0.12	5.18	0.14	0.82	7.74	7.68	100.48	2.43	n.d.
00DKA018b	55.47	15.00	0.09	3.41	4.74	0.20	4.72	0.14	0.78	6.51	9.14	100.22	4.50	n.d.
00DKA018c	48.90	13.21	0.10	2.83	11.03	0.16	3.92	0.15	0.67	5.11	13.44	99.50	9.46	0.01
00DKA018d	55.66	15.04	0.09	3.26	5.51	0.18	4.62	0.15	0.79	5.34	9.51	100.14	5.05	0.01
00DKA018e	56.14	10.83	0.15	2.52	10.58	0.42	3.32	0.15	0.68	3.00	12.18	99.97	9.26	0.01
00DKA018f	55.96	14.91	0.08	2.85	4.97	0.18	4.69	0.15	0.80	6.58	8.75	99.91	4.27	0.01
00DKA018g	51.57	15.11	0.09	3.03	7.84	0.11	4.55	0.14	0.73	5.09	11.39	99.65	6.84	0.01
00DKA018h	49.85	15.22	0.10	3.01	7.93	0.11	4.52	0.14	0.72	6.75	11.40	99.75	6.78	0.01
00DKA018i	45.21	12.08	0.13	3.06	14.72	0.12	3.41	0.15	0.60	3.28	16.58	99.34	12.90	0.02
00DKA018j	51.68	15.68	0.10	3.39	5.82	0.11	4.80	0.14	0.75	7.22	10.47	100.16	5.39	0.01
00DKA018k	50.85	15.59	0.10	3.35	6.33	0.10	4.66	0.14	0.73	7.07	11.00	99.91	5.92	0.01
00DKA019a	49.06	14.12	0.07	4.72	7.56	0.14	4.41	0.21	0.68	5.48	11.85	98.31	8.72	1.35
00DKA020a	37.64	12.20	0.08	4.26	16.17	0.16	4.01	0.14	0.50	5.46	18.79	99.41	14.90	0.02
00DKA020b	40.49	12.62	0.08	4.62	14.21	0.13	3.64	0.14	0.55	5.25	17.81	99.55	13.90	0.02
00DKA020c	36.32	10.01	0.11	7.46	16.63	0.12	3.35	0.16	0.47	3.35	21.99	99.98	18.80	0.02
00DKA020d	43.47	5.22	0.11	8.01	16.86	0.14	2.43	0.18	0.36	2.00	21.89	100.68	20.50	0.01
00DKA020e	53.49	13.93	0.07	4.42	6.45	0.14	4.56	0.19	0.79	4.59	11.57	100.18	7.30	0.02
00DKA025a	43.13	10.75	0.12	7.56	10.94	0.09	3.66	0.14	0.57	4.95	17.97	99.87	15.00	0.03
00DKA025b	36.81	7.63	0.14	9.89	15.20	0.09	3.06	0.14	0.42	4.21	22.99	100.57	20.80	0.03
00DKA025d	37.92	7.43	0.14	8.86	14.82	0.12	2.67	0.12	0.43	4.66	22.28	99.45	20.10	0.05
00DKA025e	53.50	12.36	0.07	4.09	7.24	0.11	4.79	0.15	0.69	5.20	11.85	100.04	7.72	0.02
00DKA025g	43.13	13.69	0.09	5.78	9.64	0.13	4.22	0.11	0.60	7.18	15.26	99.82	11.10	0.04
00DKA025l	46.47	15.33	0.08	5.44	7.87	0.12	4.61	0.13	0.67	5.62	13.43	99.77	9.24	0.14
00DKA025m	13.24	3.69	0.09	2.99	41.34	0.11	1.12	0.07	0.14	1.74	35.28	99.82	34.10	0.24

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA025o	42.14	13.74	0.08	5.48	11.60	0.12	4.06	0.12	0.59	5.27	16.49	99.70	12.50	0.05
00DKA025p	9.03	2.60	0.08	2.19	45.71	0.08	0.78	0.04	0.10	1.45	38.08	100.14	36.70	0.12
00DKA026a	35.23	10.96	0.09	6.30	16.83	0.13	3.70	0.15	0.46	4.73	21.62	100.20	17.70	0.02
00DKA026b	36.67	12.09	0.09	6.29	14.57	0.14	3.56	0.13	0.50	5.39	19.96	99.39	16.30	0.02
00DKA026c	32.40	7.98	0.10	7.16	21.63	0.13	2.77	0.14	0.42	2.68	24.99	100.41	22.50	0.03
00DKA026d	36.57	12.09	0.08	4.71	16.30	0.18	4.05	0.15	0.48	5.50	19.49	99.60	15.40	0.02
00DKA026e	38.02	11.82	0.08	5.24	15.68	0.14	3.99	0.12	0.51	5.05	19.16	99.80	15.50	0.02
00DKA026f	48.28	13.09	0.08	5.21	8.81	0.15	4.28	0.18	0.68	4.41	14.33	99.50	10.30	0.04
00DKA026g	53.90	15.53	0.06	3.94	5.05	0.15	5.01	0.19	0.73	5.29	9.72	99.57	5.64	0.24
00DKA027a	41.65	14.80	0.08	3.19	11.03	0.14	3.97	0.13	0.58	6.05	17.80	99.44	9.71	0.02
00DKA027b	37.76	11.60	0.10	3.51	17.42	0.16	3.88	0.13	0.50	4.20	20.21	99.46	15.40	0.02
00DKA027c	34.42	10.74	0.08	4.21	17.06	0.16	3.46	0.13	0.45	4.61	24.31	99.64	15.80	0.02
00DKA027d	38.30	14.73	0.08	3.35	12.90	0.13	3.43	0.12	0.53	5.42	20.38	99.37	11.50	0.02
00DKA027e	30.37	12.79	0.10	3.32	22.21	0.17	2.77	0.14	0.37	2.85	24.92	100.02	19.10	0.02
00DKA027f	36.88	13.38	0.08	3.54	14.01	0.15	3.37	0.12	0.51	5.78	21.41	99.22	12.80	0.02
00DKA028a	41.84	12.48	0.11	4.90	11.90	0.10	3.35	0.12	0.55	4.32	19.96	99.64	12.50	0.02
00DKA029a	49.40	12.84	0.10	3.19	9.10	0.20	3.78	0.14	0.66	6.79	13.78	99.99	7.96	0.01
00DKA030a	42.42	14.34	0.08	3.10	10.39	0.13	3.89	0.13	0.60	6.25	18.06	99.39	9.07	0.01
00DKA030b	41.95	14.36	0.08	3.03	10.96	0.11	3.78	0.12	0.59	5.99	18.45	99.42	9.51	0.01
00DKA031a	45.24	13.74	0.09	3.16	9.52	0.12	3.99	0.13	0.63	6.39	16.64	99.66	8.27	0.01
00DKA031b	43.81	12.81	0.09	3.31	11.71	0.12	3.65	0.14	0.65	5.24	17.98	99.50	10.40	0.01
00DKA031c	49.76	17.18	0.07	3.28	6.89	0.15	4.48	0.13	0.72	7.21	10.39	100.25	6.12	0.01
00DKA031d	43.97	13.94	0.09	2.90	12.05	0.13	3.97	0.13	0.62	6.32	15.34	99.47	10.10	0.02
00DKA031e	27.54	5.28	0.16	2.10	32.53	0.13	1.95	0.18	0.31	1.64	28.28	100.10	26.20	0.03
00DKA032a	48.08	15.00	0.10	3.03	9.29	0.12	4.38	0.14	0.68	7.10	11.94	99.87	7.62	0.01
00DKA032b	46.20	13.64	0.10	3.22	11.22	0.11	4.00	0.13	0.65	5.84	14.48	99.58	9.66	0.02
00DKA032c	42.78	11.86	0.11	3.20	15.58	0.15	3.95	0.15	0.58	4.07	16.75	99.18	13.30	0.02
00DKA032d	52.49	15.29	0.07	3.30	5.18	0.11	4.81	0.14	0.77	7.17	10.79	100.12	4.42	n.d.
00DKA032e	41.96	11.72	0.10	3.12	16.62	0.15	3.96	0.14	0.56	3.77	17.53	99.62	14.10	0.02
00DKA032f	46.04	14.25	0.10	3.52	10.25	0.11	4.18	0.13	0.66	6.25	14.41	99.90	9.27	0.01
00DKA033a	61.90	11.15	0.12	1.94	7.80	1.35	2.81	0.15	0.67	3.09	8.75	99.73	6.20	0.03
00DKA033b	54.35	14.11	0.13	2.57	6.22	0.76	3.94	0.14	0.74	7.51	9.20	99.67	5.01	n.d.

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO ₂	Al ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	TiO ₂	Fe ₂ O ₃	LOI	TOTAL	CO ₂	S
00DKA034b	58.79	14.00	0.08	2.66	4.26	0.92	3.99	0.15	0.78	6.44	7.77	99.83	3.41	0.01
00DKA036c	42.57	11.65	0.11	2.99	15.19	0.39	3.76	0.15	0.57	5.44	16.71	99.53	12.80	0.03
00DKA036d	32.41	7.13	0.18	2.49	27.39	0.50	2.21	0.16	0.41	2.39	24.65	99.92	22.60	0.05
00DKA037a	55.03	9.36	0.21	1.69	13.67	1.25	2.10	0.12	0.51	2.61	13.01	99.57	11.10	0.02
00DKA037b	56.64	15.16	0.08	2.78	4.03	0.68	4.28	0.14	0.80	7.65	7.99	100.23	3.20	0.01
00DKA037c	51.19	8.04	0.23	1.96	16.30	1.11	1.97	0.14	0.48	3.54	15.09	100.05	13.40	0.02
00DKA038b	54.84	15.70	0.07	3.06	4.80	0.49	4.58	0.14	0.79	6.92	8.45	99.83	3.88	0.01
00DKA040a	49.20	12.68	0.11	3.03	11.04	0.67	3.41	0.14	0.64	5.49	13.18	99.61	9.68	0.02
00DKA040b	50.31	13.04	0.11	3.05	10.09	0.66	3.57	0.14	0.67	5.74	12.43	99.80	8.81	0.02
00DKA040c	48.88	7.94	0.16	2.32	17.31	1.13	2.11	0.15	0.52	2.33	16.52	99.37	14.40	0.02
00DKA040e	47.22	13.14	0.11	2.98	11.56	0.56	3.56	0.13	0.66	5.69	13.74	99.34	9.87	0.02
00DKA040f	38.06	7.14	0.19	2.56	24.06	0.73	2.04	0.15	0.42	2.87	22.01	100.22	19.90	0.02
00DKA040h	39.76	6.94	0.18	2.38	23.42	0.86	1.95	0.16	0.49	2.57	21.29	100.01	19.30	0.02
00DKA041a	56.62	15.87	0.08	3.96	2.90	0.13	5.13	0.14	0.80	6.61	8.09	100.34	3.26	0.01
00DKA041b	53.18	12.38	0.14	5.85	6.84	0.15	4.12	0.14	0.72	3.84	12.86	100.21	9.82	0.01
00DKA041c	53.62	15.46	0.10	4.91	3.85	0.12	4.95	0.14	0.78	6.57	9.95	100.45	5.12	0.02
00DKA042a	56.68	15.92	0.08	3.36	3.10	0.16	4.95	0.14	0.81	7.14	7.90	100.24	2.86	n.d.
00DKA042b	56.83	12.86	0.13	3.56	7.02	0.44	3.86	0.16	0.79	3.70	10.57	99.92	7.01	0.01
00DKA042c	53.94	15.96	0.08	3.50	3.61	0.13	5.06	0.13	0.79	7.84	8.29	99.34	3.36	0.01
00DKA042d	58.22	12.70	0.12	3.06	6.74	0.50	3.84	0.15	0.74	3.68	9.79	99.52	6.19	0.01
00DKA042e	56.66	15.39	0.08	3.36	3.56	0.17	4.92	0.14	0.81	7.15	8.04	100.28	3.35	0.01
00DKA042f	54.31	16.43	0.09	3.75	3.07	0.11	5.11	0.14	0.79	8.14	8.32	100.25	3.10	0.01
00DKA042g	55.94	16.16	0.08	3.89	2.66	0.13	5.10	0.14	0.81	7.21	8.11	100.24	3.03	0.01
00DKA042h	61.92	12.68	0.10	3.36	4.52	0.47	4.12	0.16	0.84	3.76	8.16	100.11	4.94	0.01
00DKA042i	58.19	16.41	0.07	3.61	1.39	0.15	5.25	0.14	0.83	7.73	6.58	100.34	1.57	0.01
00DKA042j	60.50	16.94	0.05	3.10	0.65	0.02	5.34	0.16	0.91	5.08	5.74	98.48	0.31	0.26
00DKA043a	58.94	17.62	0.06	3.29	0.44	0.34	5.47	0.17	0.96	6.84	6.43	100.55	0.21	0.01
00DKA043b	60.88	14.16	0.10	2.96	3.90	0.64	4.12	0.15	0.83	4.36	7.74	99.85	3.42	0.01
00DKA043c	57.94	15.23	0.07	2.71	3.52	0.47	4.51	0.15	0.83	7.03	7.80	100.26	2.65	0.02
00DKA043d	56.61	16.38	0.07	3.08	2.49	0.41	4.94	0.13	0.83	7.48	7.85	100.28	2.13	0.01
00DKA043e	58.48	15.57	0.09	3.06	3.93	0.58	4.63	0.15	0.82	4.14	8.64	100.10	3.25	0.04
00DKA043f	60.34	14.31	0.08	2.51	4.85	0.92	4.00	0.14	0.78	3.73	8.27	99.92	3.88	0.03

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %, double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
00DKA043g	58.11	14.83	0.10	2.80	4.24	0.85	4.09	0.15	0.83	6.01	8.11	100.13	3.47	0.02
00DKA043h	58.67	13.16	0.10	2.27	6.81	1.14	3.25	0.15	0.77	3.97	8.97	99.26	5.06	0.27
00DKA043i	54.66	15.20	0.07	2.77	4.85	0.70	4.29	0.14	0.80	6.65	7.25	97.38	2.14	1.11
00DKA043j	59.27	12.24	0.13	2.31	7.71	1.20	3.00	0.15	0.74	3.11	9.39	99.27	6.05	0.27
00DKA043k	56.61	15.57	0.07	2.90	3.36	0.72	4.51	0.15	0.82	7.40	7.96	100.06	2.66	0.02
00DKA043l	57.22	14.35	0.07	2.51	5.25	0.89	3.98	0.15	0.79	6.19	8.65	100.05	4.09	0.04
00DKA043m	60.11	12.88	0.11	2.47	6.24	1.21	3.32	0.16	0.78	3.35	9.14	99.77	4.99	0.10
00DKA043n	55.88	15.07	0.08	3.01	4.28	0.76	4.30	0.15	0.81	7.04	8.66	100.05	3.47	0.02
00DKA043o	58.62	14.22	0.08	2.78	4.45	1.00	3.88	0.15	0.80	6.26	8.33	100.58	3.58	0.02
00DKA043p	55.22	12.72	0.14	2.59	8.17	1.10	3.19	0.15	0.71	5.10	10.80	99.89	6.84	0.05
00DKA043q	58.24	13.61	0.11	2.69	5.77	1.14	3.63	0.15	0.79	4.98	9.01	100.12	4.78	0.02
00DKA043r	59.85	13.32	0.09	2.44	5.60	1.27	3.51	0.16	0.79	4.37	8.59	99.99	4.50	0.02
00DKA043s	52.52	13.07	0.12	2.60	8.87	1.00	3.44	0.15	0.70	5.64	11.63	99.73	7.41	0.02
00DKA043t	52.78	10.25	0.17	2.19	12.78	1.31	2.31	0.14	0.60	3.20	13.72	99.45	10.90	0.03
00DKA043u	50.70	11.22	0.16	2.30	12.61	1.16	2.48	0.15	0.64	4.33	13.83	99.58	10.50	0.03
00DKA043v	55.78	13.52	0.11	2.72	6.65	1.19	3.69	0.16	0.71	5.75	9.61	99.89	5.60	0.03
00DKA043w	50.89	11.74	0.17	2.46	12.11	1.08	2.77	0.14	0.68	4.34	13.34	99.73	10.00	0.02
00DKA043x	52.23	10.22	0.20	2.57	13.03	1.37	2.23	0.17	0.68	3.10	13.80	99.60	11.20	0.02
00DKA043y	55.79	13.87	0.11	2.90	5.87	1.14	3.83	0.16	0.78	6.26	9.23	99.96	4.99	0.02
00DKA043z	57.94	13.38	0.11	2.62	5.38	1.29	3.50	0.17	0.85	5.15	8.64	99.01	4.63	0.03
00DKA-053aa	51.34	8.38	0.09	5.83	11.12	0.10	3.14	0.24	0.58	2.56	15.73	99.09	13.90	0.14
00DKA-053a	42.16	13.48	0.08	4.34	11.83	0.15	3.97	0.13	0.59	5.90	16.74	99.36	11.60	0.03
00DKA-053b	39.66	12.97	0.08	4.10	14.73	0.16	3.67	0.13	0.55	5.57	17.61	99.22	13.90	0.02
00DKA-053c	38.85	12.14	0.08	4.11	15.64	0.16	4.10	0.14	0.52	5.62	17.86	99.22	14.30	0.02
00DKA-053d	37.70	11.61	0.09	4.37	16.70	0.19	3.90	0.14	0.50	5.51	18.86	99.56	15.60	0.03
00DKA-053e	38.98	12.71	0.09	3.73	15.13	0.19	4.27	0.15	0.52	5.91	17.35	99.02	13.60	0.02
00DKA-053f	48.60	16.12	0.06	3.28	6.28	0.18	4.94	0.13	0.70	7.26	12.17	99.71	5.19	0.06
00DKA-053g	44.38	15.23	0.08	4.20	9.37	0.22	4.56	0.14	0.65	6.94	13.94	99.70	9.07	0.03
00DKA-053h	44.33	15.13	0.08	4.34	9.16	0.21	4.56	0.14	0.64	6.45	14.87	99.91	9.03	0.02
00DKA-053i	40.97	13.70	0.09	4.55	12.32	0.22	4.03	0.13	0.58	6.10	16.73	99.41	12.30	0.03
00DKA-053j	41.29	13.96	0.09	4.72	11.70	0.24	4.12	0.13	0.58	6.47	16.13	99.44	11.80	0.03
00DKA-053k	42.78	14.74	0.08	3.88	9.82	0.25	4.35	0.13	0.61	7.10	15.85	99.58	9.21	0.02

Appendix 5: major and minor element data for bed samples (see Appendix 3 for sample descriptions and locations; all data in weight %; double lines separate samples from different stations; analytical detection limits listed at end of table).

Sample #	SiO2	Al2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	TiO2	Fe2O3	LOI	TOTAL	CO2	S
00DKA-053m	31.39	9.44	0.11	3.01	24.14	0.27	3.18	0.13	0.38	3.51	23.96	99.52	20.40	0.04
00DKA-053n	38.81	13.24	0.09	4.56	12.92	0.23	3.82	0.12	0.54	6.52	18.58	99.41	12.70	0.03
00DKA-053o	5.32	1.70	0.13	3.26	48.05	0.09	0.47	0.04	0.05	0.68	40.46	100.25	39.80	0.05
00DKA-053p	36.77	12.20	0.10	4.25	16.50	0.27	3.98	0.13	0.48	4.36	20.19	99.23	15.40	0.04
00DKA-053q	42.03	7.64	0.09	2.79	19.67	0.26	3.22	0.12	0.43	3.14	18.98	98.35	16.70	0.45
00DKA-053r	33.88	10.23	0.11	6.34	17.82	0.25	3.38	0.12	0.44	3.98	22.61	99.17	18.60	0.25
00DKA-053s	38.48	11.73	0.10	6.42	11.42	0.26	3.51	0.12	0.53	5.42	16.83	94.81	10.80	2.02
00DKA-053t	30.10	9.39	0.10	6.24	15.46	0.21	2.94	0.09	0.41	4.00	19.43	88.38	11.10	4.42
00DKA-053u	36.31	9.49	0.13	7.85	14.20	0.17	2.97	0.11	0.49	4.14	21.03	96.89	16.70	1.04
00DKA-053v	42.68	12.18	0.10	5.52	10.88	0.20	3.71	0.12	0.58	4.48	18.12	98.58	12.70	1.14
00DKA-053w	44.16	12.51	0.11	5.55	10.94	0.22	3.82	0.12	0.60	4.49	16.01	98.54	11.50	0.46
00DKA-053x	46.81	12.74	0.10	4.74	9.18	0.24	3.97	0.13	0.63	6.54	13.42	98.49	8.59	0.74
00DKA-053y	50.54	12.98	0.09	4.71	7.11	0.24	4.27	0.14	0.69	6.50	12.77	100.05	8.11	0.03
00DKA-053z	39.97	7.78	0.13	6.16	17.38	0.34	2.87	0.14	0.41	3.47	20.67	99.31	19.20	0.27
detection limits:	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	n/a	0.03	0.01

APPENDIX 6

Trace element data for Milton core (OGS-83-01) samples (modified after Armstrong 2001).

Appendix 6: trace element data for Milton core (OGS-83-1) samples (see Appendix 3 for sample descriptions and locations; all data in ppm, except Ag and Au, which are reported in ounces per tonne).

Sample #	As	Al	Ba	Be	Ca	Cd	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu
00DKA001a	17.22	88105.20	354.51	3.26	36808.50	n.d.	88.227	13.85	83.35	6.974	47.25	5.191	3.012	1.455
00DKA001b	5.77	95157.50	345.00	2.82	28748.50	n.d.	90.840	14.79	87.71	7.590	13.78	4.755	2.756	1.450
00DKA001c	12.75	94015.90	350.94	2.78	73164.20	n.d.	86.713	15.38	79.36	6.919	13.34	4.796	2.601	1.438
00DKA001d	4.01	94203.80	413.34	2.55	52393.70	n.d.	91.600	16.16	81.01	7.160	13.85	4.986	2.807	1.469
00DKA001e	11.73	103123.00	402.08	2.72	50577.40	n.d.	95.042	18.57	84.43	8.309	14.82	4.790	2.729	1.468
00DKA001f	26.79	88472.80	484.42	2.54	75075.40	n.d.	85.506	18.20	73.09	6.809	13.83	4.878	2.795	1.417
00DKA001g	13.78	50457.20	429.90	n.d.	79499.40	n.d.	56.656	13.98	43.71	4.714	10.60	4.152	2.393	1.188
00DKA001h	16.61	62250.80	495.25	2.40	53713.50	n.d.	68.548	18.85	49.08	6.079	18.64	4.533	2.536	1.371
00DKA001i	20.75	53553.80	336.24	2.03	96361.40	n.d.	64.967	15.69	42.78	5.405	16.24	4.393	2.451	1.294
00DKA001j	8.46	67102.40	342.96	2.38	61884.80	n.d.	72.656	16.85	57.47	5.790	17.99	4.572	2.677	1.329
00DKA001k	19.78	64514.70	302.93	2.34	90713.80	n.d.	66.444	16.09	62.32	6.203	12.17	3.986	2.399	1.222
00DKA001l	17.40	50179.00	255.04	n.d.	119166.00	n.d.	63.349	13.35	47.73	4.681	12.19	4.300	2.439	1.197
00DKA001m	16.65	57631.80	481.99	2.12	76750.20	n.d.	64.480	15.44	48.17	5.578	12.34	3.996	2.258	1.180
00DKA001n	15.08	47592.80	283.86	2.28	132446.00	n.d.	61.782	13.37	47.49	4.477	11.87	4.250	2.344	1.165
00DKA001o	8.05	61831.00	538.32	2.02	54422.40	n.d.	65.795	15.03	49.42	4.668	12.92	4.667	2.529	1.342
00DKA001p	12.98	48717.30	281.96	n.d.	98141.80	n.d.	65.107	13.38	36.63	3.768	10.57	5.014	2.765	1.383
00DKA001q	11.21	55999.10	333.13	n.d.	77736.50	n.d.	68.744	14.30	55.58	4.654	11.90	4.673	2.510	1.331
00DKA001r	9.87	71037.90	386.82	n.d.	45841.90	n.d.	71.606	14.78	53.86	5.486	11.87	4.820	2.737	1.356
00DKA001s	8.66	64090.30	477.94	n.d.	52823.10	n.d.	67.042	13.56	55.96	4.932	11.17	4.671	2.644	1.319
00DKA001t	12.75	76949.70	409.33	2.38	51250.20	n.d.	78.667	15.47	54.47	6.782	12.50	4.719	2.746	1.347
00DKA001u	10.27	83890.10	419.07	2.62	34879.60	n.d.	81.267	15.86	65.23	7.238	12.47	4.620	2.619	1.420
00DKA001v	8.53	73371.00	330.27	2.04	63038.50	n.d.	77.798	14.56	62.62	5.994	13.39	4.714	2.545	1.369
00DKA001w	4.65	89536.40	357.10	2.74	18246.40	n.d.	83.366	17.02	78.87	7.922	16.16	4.581	2.621	1.315
00DKA001x	4.19	90312.20	387.38	2.55	22056.30	n.d.	79.849	16.44	81.28	7.060	36.12	4.813	2.806	1.428
00DKA001y	14.28	54490.90	338.90	n.d.	91699.20	n.d.	61.869	9.96	45.35	3.492	167.74	4.573	2.525	1.352
00DKA001z	8.34	90384.10	331.32	2.34	30795.10	n.d.	83.252	18.22	78.79	7.751	54.22	4.422	2.615	1.270
00DKA001aa	7.79	81447.70	311.87	2.08	42977.30	n.d.	73.542	16.15	60.28	5.919	52.35	4.613	2.545	1.364
Maximum:	26.79	103123.00	538.32	3.26	132446.00	n.d.	95.042	18.85	87.71	8.309	167.74	5.191	3.012	1.469
Average:	12.16	72541.42	377.11	2.45	63378.19	n.d.	74.619	15.38	61.71	6.013	24.16	4.610	2.608	1.342
Minimum:	4.01	47592.80	255.04	n.d.	18246.40	n.d.	56.656	9.96	36.63	3.492	10.57	3.986	2.258	1.165
detection limits:	3.50	100.00	5.00	2.00	100.00	1.00	0.200	1.00	1.00	0.100	2.00	0.300	0.050	0.200
analytical methods:	ICP-AES	ICP-MS												

Appendix 6: trace element data for Milton core (OGS-83-1) samples (see Appendix 3 for sample descriptions and locations; all data in ppm, except Ag and Au, which are reported in ounces per tonne).

Sample #	Fe	Ga	Gd	Hf	Ho	La	Li	Lu	Mg	Mn	Mo	Nb	Nd	Ni
00DKA001a	46170.80	21.52	6.109	3.53	1.148	41.527	67.86	0.471	35692.00	668.52	1.38	13.37	37.07	44.20
00DKA001b	67220.30	21.80	5.770	3.29	1.023	40.888	70.28	0.398	33344.70	653.01	1.43	13.54	37.23	46.08
00DKA001c	66192.60	20.20	5.865	3.15	1.008	38.692	67.11	0.387	34677.50	909.80	1.13	12.43	36.17	46.16
00DKA001d	63622.60	20.23	6.167	3.22	1.020	41.902	73.38	0.420	29110.70	693.50	1.26	12.69	37.96	45.80
00DKA001e	64132.00	22.32	6.118	3.38	1.009	42.388	80.68	0.408	30001.90	714.65	2.37	13.92	38.25	52.08
00DKA001f	52990.10	19.69	5.995	3.56	1.034	38.494	71.33	0.397	28238.20	915.23	5.83	13.28	36.19	46.27
00DKA001g	25720.30	14.74	4.933	3.52	0.873	28.535	59.57	0.355	15941.60	482.38	n.d.	10.75	28.46	32.92
00DKA001h	36230.90	19.30	5.482	3.42	0.978	35.722	69.30	0.385	16996.90	534.19	4.51	12.91	33.28	39.90
00DKA001i	36746.50	15.92	5.379	3.45	0.909	33.606	60.57	0.372	18028.80	700.35	1.28	11.53	32.00	36.24
00DKA001j	43322.20	18.01	5.712	3.46	0.989	34.263	65.03	0.403	20724.30	622.28	1.43	12.79	33.27	39.99
00DKA001k	48919.50	18.63	4.823	3.04	0.831	33.655	62.90	0.359	18715.60	629.71	1.59	11.17	30.00	39.77
00DKA001l	32479.50	13.90	5.243	4.27	0.916	31.164	53.03	0.380	17496.00	746.00	1.45	10.67	29.61	33.81
00DKA001m	43331.50	17.56	4.910	3.28	0.843	31.988	64.19	0.360	17757.40	578.79	1.48	11.64	29.12	35.37
00DKA001n	27926.00	13.66	5.150	3.74	0.910	30.399	50.60	0.355	17869.10	842.49	1.24	10.07	29.41	33.96
00DKA001o	39586.10	15.39	5.580	4.12	0.994	30.865	57.82	0.402	18293.00	672.21	1.33	12.49	30.98	35.33
00DKA001p	25368.20	12.71	6.027	4.14	1.051	30.531	49.52	0.407	19564.80	955.15	n.d.	11.23	32.90	32.74
00DKA001q	28987.70	15.51	5.687	3.42	0.965	33.447	52.31	0.386	19410.60	825.56	1.11	11.65	32.23	34.92
00DKA001r	46189.90	17.75	5.935	4.22	1.014	34.591	54.90	0.420	19174.60	624.37	1.81	12.92	33.12	37.05
00DKA001s	42648.10	15.77	5.458	3.27	0.975	32.033	47.72	0.357	17007.30	642.05	1.98	11.44	31.14	34.94
00DKA001t	64304.10	19.13	5.765	3.46	0.997	38.053	52.80	0.390	19589.10	660.09	2.57	13.32	34.25	40.32
00DKA001u	71680.40	20.02	5.819	3.36	0.981	39.663	51.48	0.423	20683.90	585.71	2.63	13.54	36.30	41.20
00DKA001v	45010.80	17.30	5.628	3.54	1.015	36.455	50.12	0.391	18163.70	892.03	1.92	12.71	35.26	39.04
00DKA001w	63882.80	21.19	5.588	3.35	1.003	39.600	60.81	0.409	21261.40	434.16	2.14	13.66	35.68	45.65
00DKA001x	68952.00	20.48	5.902	4.28	1.054	36.713	56.95	0.431	19751.10	444.59	2.69	14.79	36.17	43.09
00DKA001y	42544.30	11.87	5.917	3.86	0.966	26.886	38.46	0.373	14520.40	1000.94	1.06	10.20	30.65	30.32
00DKA001z	53499.90	22.08	5.614	3.29	0.952	39.407	58.34	0.411	25954.50	669.24	n.d.	13.45	35.00	44.79
00DKA001aa	49562.50	18.21	5.862	3.40	0.990	34.065	55.51	0.388	25874.00	875.94	n.d.	12.46	33.94	39.58
Maximum:	71680.40	22.32	6.167	4.28	1.148	42.390	80.68	0.471	35692.00	1000.94	5.83	14.79	38.25	52.08
Average:	47971.17	17.96	5.646	3.56	0.980	35.390	59.35	0.394	21994.19	702.70	1.98	12.39	33.54	39.69
Minimum:	25368.20	11.87	4.823	3.04	0.831	26.890	38.46	0.355	14520.40	434.16	n.d.	10.07	28.46	30.32
detection limits:	5.00	1.00	0.300	0.01	0.200	0.200	1.00	0.010	20.00	0.10	1.00	0.02	0.50	5.00
analytical methods:	ICP-MS													

Appendix 6: trace element data for Milton core (OGS-83-1) samples (see Appendix 3 for sample descriptions and locations; all data in ppm, except Ag and Au, which are reported in ounces per tonne).

Sample #	Pb	Pr	Rb	Sb	Sc	Sm	Sn	Sr	Ta	Tb	Th	Ti	Ti	Tm	U	V
00DKA001a	23.93	10.052	148.76	0.60	14.81	6.888	2.87	78.3	0.99	0.972	10.78	4305.96	0.87	0.462	2.563	139.51
00DKA001b	9.32	10.178	152.99	0.71	14.74	7.096	2.89	87.3	1.02	0.902	11.07	4499.43	0.84	0.404	2.833	146.39
00DKA001c	9.28	9.724	142.47	0.76	14.56	6.959	2.63	128.9	0.93	0.933	9.80	4519.56	0.71	0.372	2.106	137.92
00DKA001d	9.68	10.447	145.08	0.79	14.86	7.111	2.78	136.7	0.97	0.951	10.68	4411.84	0.74	0.428	2.079	133.56
00DKA001e	10.88	10.480	157.37	0.73	15.95	7.266	2.93	147.8	1.04	0.907	10.94	4927.13	0.83	0.432	2.531	150.00
00DKA001f	11.40	9.667	141.15	0.62	15.22	7.030	2.76	221.4	1.00	0.925	10.16	4200.81	0.72	0.414	2.686	131.44
00DKA001g	7.20	7.298	102.48	n.d.	12.29	5.650	2.22	304.8	0.80	0.799	8.55	2809.41	0.56	0.356	2.150	77.46
00DKA001h	14.66	8.891	128.32	0.53	14.00	6.295	2.57	245.9	0.96	0.840	10.56	3260.06	0.71	0.403	2.984	100.03
00DKA001i	11.80	8.402	113.69	0.56	12.16	6.086	2.45	325.4	0.85	0.820	9.01	2976.08	0.58	0.350	2.220	80.18
00DKA001j	13.02	8.767	119.94	0.52	13.66	6.361	2.71	171.9	0.96	0.871	9.57	3660.63	0.58	0.399	2.282	92.61
00DKA001k	18.60	8.034	130.50	0.64	14.01	5.648	2.16	222.9	0.90	0.755	9.05	3149.88	0.64	0.346	2.293	96.91
00DKA001l	15.34	7.865	101.31	n.d.	12.48	5.782	1.78	201.2	0.79	0.830	8.41	2877.75	0.47	0.374	2.310	74.72
00DKA001m	16.01	7.946	118.08	0.59	13.74	5.446	2.13	306.3	0.85	0.746	8.93	3015.08	0.56	0.347	2.250	77.74
00DKA001n	13.65	7.684	99.58	n.d.	11.45	5.749	1.73	353.4	0.74	0.801	7.92	2709.23	0.48	0.363	2.267	73.10
00DKA001o	12.31	8.213	103.07	0.53	11.60	6.010	1.89	275.7	0.92	0.848	8.79	3578.44	0.51	0.388	2.615	89.64
00DKA001p	10.17	8.416	84.97	n.d.	10.19	6.629	1.63	232.5	0.85	0.950	8.08	3082.40	0.41	0.401	2.424	67.64
00DKA001q	10.38	8.509	102.57	n.d.	11.94	6.277	1.90	146.6	0.85	0.894	8.47	3262.79	0.46	0.387	3.308	85.59
00DKA001r	13.19	8.812	117.23	0.58	12.72	6.784	2.29	157.9	0.94	0.887	9.98	3695.63	0.57	0.416	2.686	95.24
00DKA001s	11.84	8.280	107.84	0.64	11.37	6.351	2.10	179.5	0.91	0.882	9.26	3258.59	0.56	0.387	2.293	91.51
00DKA001t	15.48	9.130	138.89	0.84	12.80	6.700	2.55	164.7	1.01	0.875	10.98	3918.69	0.70	0.399	2.396	116.04
00DKA001u	14.86	9.814	142.88	0.90	13.49	6.632	2.62	193.2	1.06	0.874	11.51	4072.76	0.73	0.395	2.837	127.04
00DKA001v	11.01	9.083	121.89	0.56	12.53	6.594	2.32	328.6	0.98	0.890	10.39	3865.48	0.65	0.395	3.138	111.51
00DKA001w	10.53	9.781	155.70	0.87	15.04	6.520	2.96	101.2	1.08	0.859	11.77	4200.34	0.82	0.395	3.076	145.76
00DKA001x	10.94	9.544	147.80	0.90	14.70	6.848	2.67	116.0	1.13	0.948	12.04	4537.64	0.75	0.434	3.285	143.77
00DKA001y	10.49	7.706	80.76	0.54	8.58	6.164	1.56	216.7	0.77	0.876	7.73	2994.31	0.45	0.362	2.203	80.92
00DKA001z	6.28	9.593	153.19	n.d.	14.77	6.574	2.83	110.1	1.05	0.859	11.41	4325.61	0.77	0.398	3.271	142.61
00DKA001aa	5.81	9.030	124.47	n.d.	12.30	6.877	2.40	115.8	0.94	0.911	10.20	3879.62	0.70	0.388	2.897	120.33
Maximum:	23.93	10.480	157.37	0.90	15.95	7.266	2.96	353.4	1.13	0.972	12.04	4927.13	0.87	0.462	3.308	150.00
Average:	12.15	8.939	125.30	0.67	13.18	6.457	2.38	195.2	0.94	0.874	9.85	3703.52	0.64	0.392	2.592	108.49
Minimum:	5.81	7.298	80.76	n.d.	8.58	5.446	1.56	78.3	0.74	0.746	7.73	2709.23	0.41	0.346	2.079	67.64
detection limits:	0.10	0.200	1.00	0.50	0.50	0.500	0.10	2.0	0.50	0.500	0.50	10.00	0.30	0.300	0.030	1.00
analytical methods:																
ICP-MS																

Appendix 6: trace element data for Milton core (OGS-83-1) samples (see Appendix 3 for sample descriptions and locations; all data in ppm, except Ag and Au, which are reported in ounces per tonne).

Sample #	W	Y	Yb	Zn	Zr	Ag	Au
00DKA001a	1.34	28.60	3.118	132.56	113.76	n.d.	n.d.
00DKA001b	1.19	25.88	2.752	81.17	106.56	n.d.	n.d.
00DKA001c	1.18	25.74	2.626	72.86	100.74	n.d.	n.d.
00DKA001d	1.19	26.23	2.762	77.48	106.69	n.d.	trace
00DKA001e	1.26	26.47	2.843	85.66	112.40	n.d.	trace
00DKA001f	1.17	25.83	2.781	76.41	119.71	n.d.	n.d.
00DKA001g	0.90	22.75	2.311	64.49	115.74	n.d.	n.d.
00DKA001h	1.10	24.38	2.619	80.75	113.61	n.d.	n.d.
00DKA001i	1.03	24.48	2.433	68.63	120.42	n.d.	n.d.
00DKA001j	1.13	24.78	2.645	76.25	112.51	n.d.	n.d.
00DKA001k	1.08	21.81	2.333	72.64	101.06	n.d.	n.d.
00DKA001l	0.90	24.14	2.676	63.86	148.08	n.d.	n.d.
00DKA001m	1.03	21.46	2.219	68.98	112.83	n.d.	n.d.
00DKA001n	0.80	23.68	2.393	59.44	127.56	n.d.	n.d.
00DKA001o	1.01	24.73	2.615	66.77	138.41	n.d.	n.d.
00DKA001p	0.91	28.34	2.694	58.04	139.06	n.d.	n.d.
00DKA001q	0.97	25.89	2.647	66.30	117.45	n.d.	n.d.
00DKA001r	1.09	26.61	2.656	70.07	136.38	n.d.	n.d.
00DKA001s	1.04	25.87	2.475	65.68	109.76	n.d.	n.d.
00DKA001t	1.21	26.56	2.718	72.99	115.08	n.d.	n.d.
00DKA001u	1.40	26.23	2.642	75.41	113.84	n.d.	n.d.
00DKA001v	1.11	26.25	2.676	69.79	119.67	n.d.	n.d.
00DKA001w	1.30	25.83	2.622	83.29	113.17	n.d.	n.d.
00DKA001x	1.34	26.83	2.922	82.23	137.35	n.d.	n.d.
00DKA001y	0.87	25.31	2.463	50.40	129.38	n.d.	n.d.
00DKA001z	1.22	25.51	2.650	83.01	112.03	n.d.	n.d.
00DKA001aa	1.12	26.04	2.751	73.89	117.44	n.d.	n.d.
Maximum:	1.40	28.60	3.118	132.56	148.08	n.d.	trace
Average:	1.11	25.42	2.631	74.04	118.91	n.d.	n.d.
Minimum:	0.80	21.46	2.219	50.40	100.74	n.d.	n.d.
detection limits:	0.05	0.05	0.500	5.00	1.00	0.1	0.01
analytical methods:	ICP-MS					Gravimetric Fire Assay	

APPENDIX 7

Major and minor element data and depth intervals of samples from OGS 1989 drill holes
(data from Rutka and Vos 1993).

Appendix 7: major and minor element data and depth intervals for samples from 1989 OGS drill holes (data from Rutka and Vos 1993).

Sample #	drill hole #	depth from (m)	depth to (m)	interval (m)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	CO ₂	S	L.O.I.	Total	Cl	F
1	OGS-89-05a	3.05	5.49	2.44	41.80	9.57	4.06	1.86	19.00	0.73	2.74	0.55	0.15	0.12	15.00	0.02	18.20	98.80	1080	470
2	OGS-89-05a	5.49	7.92	2.44	43.30	11.10	4.85	2.20	16.10	0.66	3.24	0.56	0.15	0.12	12.80	0.02	17.40	99.70	170	580
3	OGS-89-05a	7.92	10.06	2.13	38.20	9.37	4.41	1.55	9.19	0.61	2.55	0.29	0.12	0.08	7.81	3.70	10.80	77.20	110	440
4	OGS-89-05a	10.06	12.50	2.44	41.80	11.30	4.63	2.31	16.70	0.41	3.31	0.60	0.14	0.12	13.50	0.04	17.10	98.40	1080	550
5	OGS-89-05a	12.50	14.63	2.13	44.90	11.90	5.50	2.43	13.90	0.54	3.40	0.65	0.15	0.10	11.50	0.04	14.80	98.30	220	570
23	OGS-89-05a	14.63	19.20	4.57	45.20	11.30	4.59	2.19	13.80	0.75	3.12	0.58	0.15	0.10	10.10	0.81	14.40	96.20	n/a	n/a
24	OGS-89-05a	19.20	23.77	4.57	48.70	13.30	6.20	2.50	10.40	0.70	3.82	0.65	0.17	0.10	8.64	0.03	12.40	98.90	n/a	n/a
25	OGS-89-05a	23.77	28.35	4.57	52.20	13.00	5.69	2.40	8.61	0.68	3.45	0.74	0.15	0.10	7.48	0.11	11.00	97.90	n/a	n/a
41	OGS-89-05a	28.35	37.49	9.14	51.60	13.10	5.62	2.61	8.90	0.79	3.53	0.69	0.16	0.11	7.49	0.04	11.10	98.20	n/a	n/a
42	OGS-89-05a	37.49	47.24	9.75	54.00	13.20	5.69	2.79	7.70	0.59	3.53	0.70	0.15	0.10	5.45	0.03	9.90	98.40	n/a	n/a
6	OGS-89-06	6.10	8.53	2.44	45.30	9.07	3.87	3.14	16.20	0.46	2.66	0.59	0.17	0.13	14.60	0.11	16.80	98.40	1120	440
7	OGS-89-06	8.53	10.97	2.44	53.60	13.40	5.70	4.33	6.17	0.29	3.86	0.73	0.18	0.13	7.31	0.14	10.40	98.80	1020	600
8	OGS-89-06	10.97	13.11	2.13	55.90	12.20	5.12	3.86	6.81	0.45	3.44	0.68	0.21	0.12	7.54	0.06	10.10	98.90	1060	570
9	OGS-89-06	13.11	15.54	2.44	58.00	12.90	5.52	3.22	5.31	0.53	3.72	0.75	0.20	0.11	5.82	0.08	8.60	98.90	430	590
26	OGS-89-06	15.54	20.12	4.57	53.30	14.30	5.84	3.78	5.39	0.41	4.06	0.67	0.16	0.11	5.42	0.14	10.10	98.10	n/a	n/a
27	OGS-89-06	20.12	24.69	4.57	53.70	17.60	7.16	3.52	2.18	0.44	5.02	0.85	0.22	0.08	2.44	0.13	8.20	98.80	n/a	n/a
28	OGS-89-06	24.69	29.26	4.57	52.80	16.60	7.05	3.76	3.36	0.34	4.78	0.83	0.21	0.10	3.69	0.11	9.00	99.00	n/a	n/a
43	OGS-89-06	29.26	33.22	3.96	53.70	16.50	6.99	3.64	2.85	0.21	4.62	0.79	0.22	0.10	3.21	0.16	8.20	98.00	n/a	n/a
29	OGS-89-08	17.07	18.59	1.52	44.30	9.30	3.04	2.32	17.30	0.74	2.48	0.51	0.15	0.14	14.10	0.03	17.20	97.50	n/a	n/a

Appendix 7: major and minor element data and depth intervals for samples from 1989 OGS drill holes (data from Rutka and Vos 1993).

Sample #	drill hole #	depth from (m)	depth to (m)	interval (m)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	CO ₂	S	L.O.I.	Total	Cl	F
30	OGS-89-08	18.59	23.16	4.57	48.00	13.10	5.89	2.90	10.30	0.61	3.75	0.64	0.17	0.10	8.83	0.03	12.80	98.30	n/a	n/a
31	OGS-89-08	23.16	27.74	4.57	54.00	12.90	5.63	2.83	7.88	0.58	3.44	0.68	0.16	0.10	6.84	0.12	10.40	98.60	n/a	n/a
44	OGS-89-08	27.74	36.88	9.14	52.50	13.10	5.73	2.84	8.22	0.88	3.51	0.69	0.18	0.10	6.58	0.02	10.70	98.50	n/a	n/a
45	OGS-89-08	36.88	42.98	6.10	55.50	14.30	6.55	2.61	5.23	0.73	3.97	0.72	0.17	0.08	3.96	0.02	8.40	98.30	n/a	n/a
10	OGS-89-09	3.05	4.88	1.83	58.30	14.80	6.26	2.72	4.05	0.44	4.06	0.88	0.13	0.10	2.94	0.05	7.80	99.50	1060	540
11	OGS-89-09	4.88	7.01	2.13	57.40	15.60	7.58	2.79	3.21	0.05	4.50	0.86	0.16	0.09	2.42	0.01	7.10	99.30	1080	590
12	OGS-89-09	7.01	9.45	2.44	56.80	15.90	7.26	2.82	3.54	0.28	4.54	0.86	0.16	0.09	2.64	0.01	7.60	99.80	100	610
13	OGS-89-09	9.45	11.58	2.13	58.10	14.40	5.67	2.43	4.89	0.56	4.03	0.86	0.17	0.11	3.64	0.01	8.00	99.20	140	530
14	OGS-89-09	11.58	14.02	2.44	58.70	13.90	5.94	2.20	5.40	0.83	3.84	0.85	0.16	0.10	3.83	0.01	8.00	99.00	110	470
32	OGS-89-09	14.02	18.59	4.57	56.20	15.90	7.28	2.73	3.69	0.46	4.40	0.81	0.16	0.09	2.85	0.01	7.20	98.90	n/a	n/a
33	OGS-89-09	18.59	23.16	4.57	55.60	15.50	6.74	2.71	4.29	0.49	4.30	0.79	0.16	0.09	3.28	0.05	7.80	98.50	n/a	n/a
34	OGS-89-09	23.16	27.74	4.57	51.60	13.50	5.85	2.26	7.15	0.61	3.64	0.70	0.16	0.08	3.17	1.89	9.30	94.70	n/a	n/a
46	OGS-89-09	27.74	39.01	11.28	58.10	14.40	5.88	2.63	4.54	0.65	3.88	0.77	0.17	0.09	3.43	0.13	7.50	98.60	n/a	n/a
15	OGS-89-10	6.71	9.45	2.74	57.30	12.90	6.29	2.32	6.68	0.38	3.57	0.84	0.15	0.10	5.50	0.01	8.90	99.40	110	520
16	OGS-89-10	9.45	11.58	2.13	57.10	16.40	8.64	2.86	1.97	0.50	4.64	0.88	0.14	0.06	1.52	0.01	6.60	99.80	140	680
17	OGS-89-10	11.58	14.02	2.44	54.40	13.70	7.15	2.29	7.08	0.76	3.83	0.80	0.14	0.11	5.85	0.01	9.50	99.80	210	630
35	OGS-89-10	14.02	18.59	4.57	48.30	12.70	5.00	3.05	10.70	0.65	3.39	0.61	0.16	0.13	9.71	0.09	13.00	97.70	n/a	n/a
36	OGS-89-10	18.59	23.16	4.57	55.20	12.90	4.89	3.49	6.48	0.76	3.20	0.64	0.16	0.13	7.26	0.21	10.20	98.10	n/a	n/a
37	OGS-89-10	23.16	29.57	6.40	46.60	13.00	5.73	3.78	9.86	0.80	3.40	0.63	0.14	0.14	10.00	0.71	12.70	96.80	n/a	n/a

APPENDIX 8

Quarry section descriptions (tables 1 to 6).

Table 1: Streetsville Quarry, unit descriptions (all Queenston Formation, except Unit 1)

unit #	bottom (m)	top elevation (m)	composite sample #	unit description	bed samples (00DKA-)
12	14.10	18.20	00DKA107k	14.10 - 15.45 m: interbedded red (75%) and green (25%) with evenly spaced (10 - 20 cm) green beds; 15.45 - 18.20 m: red blocky argillaceous siltstone with minor (< 10%) green beds; possibly new cycle starting at 17.65 m.	007w, x, y, z
11	12.25	14.10	00DKA107j	Interbedded red argillaceous siltstone (90%) and green argillaceous siltstone/fine-grained sandstone/limestone (10%); top 70 cm is mostly red argillaceous siltstone; basal 1.15 m interbedded interval is bounded by thin green argillaceous limestone beds; argillaceous siltstone beds are thicker parted (up to 25 cm) and harder than elsewhere; sample very muddy and possibly contaminated by overburden; ripple crests @ 178 degrees at 13.50 m.	007u, v
10	10.05	12.25	00DKA107i	Interbedded red (64%) argillaceous siltstone and green argillaceous siltstone/fine-grained sandstone/limestone (36%); sparse green beds in upper 0.75 m; tabular, green-grey argillaceous limestone bed at top.	007s, t
9	7.90	10.05	00DKA107h	lower 1/2 is interbedded red (70%) argillaceous siltstone and green (30%) fine-grained sandstone/limestone beds; top 1/2 is red argillaceous siltstone with minor discontinuous green beds; basal bed is limestone, limestone also at 8.60 - 8.65 m.	007q, r
8	6.75	7.90	00DKA107g	red (75%) argillaceous siltstone and green fine-grained sandstone/limestone (25%) interbeds; basal bed is green argillaceous limestone.	007p
7	5.15	6.75	00DKA107f	red argillaceous siltstone and fine-grained sandstone (90%) with thin green argillaceous siltstone and fine-grained sandstone beds (5%) and dark grey limestone beds (< 5%); quarry floor in SW corner is at approx. 5.75 m; ripple crests @ 125 degrees at 5.75 m	007n, o
6	4.85	5.15	00DKA107e	thick limestone bed, with sharp base, and green argillaceous siltstone	
5	3.40	4.85	00DKA107d	red argillaceous siltstone with green argillaceous siltstone band in middle and a few thin (< 15 cm) green argillaceous limestone beds; one green mudstone band at 4.00 - 4.15 m in pumphouse section, same as band at 3.80 - 3.90 m in drainage ditch.	007l, m
4	2.30	3.40	00DKA107c	interbedded grey limestone and red and green argillaceous siltstone; tabular 20 cm bed(s) at base, locally shallower to top (i.e. pumphouse); limestone beds are either tabular with horizontal lamination and rippled tops or irregular-bedded and bioclastic; top bed is ripple-topped limestone; basal bed pinches (< 5cm) and swells (25 cm) laterally with frequency of 36 m between maxima; ripple crests @ 160 degrees at 2.55 m; ripple cross-lamination @ 25 degrees at 3.25 m.	007h, i, j, k
3	1.30	2.30	00DKA107b	red argillaceous siltstone (90%), with thin (2 - 5 cm) green argillaceous siltstone (5%), and red and green fine-grained sandstone (5%) interbeds; less shale to top (?) (in pumphouse/sump section).	
2	0.00	1.30	00DKA107a	laminated red argillaceous siltstone (50%) thinly interbedded with red (45%) and green (5%) mudstones (in pumphouse/sump section).	007d, e, f, g
1	?	0.00	none	Georgian Bay Formation - interbedded grey-green mudstone and grey limestone; limestone either 1) tabular bedded, horizontal of low angle laminated, sparsely fossiliferous or 2) brachiopod- and bryozoan-rich bioclastic packstone with slightly irregular bedding; in sump, not exposed; no composite sample taken.	007a, b, c

Table 2 - Burlington Quarry unit descriptions (all Queenston Formation).

unit #	bottom elevation	top elevation	composite sample #	unit description	bed samples (00DKA-)
8	15.45	17.15	no sample	mostly red shale, with ~25% red siltstone; capped by green interval?; overlain by overburden.	-
7	13.30	15.45	00DKA102g	red shale with interbeds of red siltstone and minor green siltstone; finer grained in basal 1.1 m; still >50% muddy silt in upper part; capped by 10 - 15 cm grey-green siltstone/limestone.	002o, p, q
6	9.05	13.30	00DKA102f	red shale with thin regularly spaced red and green siltstone beds; interval @ 10.75 - 11.85 m contains more hard beds; unit capped by 2 green hard beds.	002k, l, m, n
5	5.30	9.05	00DKA102e	two cycles consisting of ~70 cm red shale overlain by 1.10 - 1.25 m intervals of interbedded red or green siltstones and red shales; top bed called "upper datum" in notes; siltstones are commonly laminated and have rippled tops.	002f, g, h, i, j
4	2.85	5.30	00DKA102d	red shale and siltstone, with minor green siltstone beds and light red-grey fine-grained limestone beds; capped by laterally persistent green bed; gypsum nodules up to 3.7 m level in main pit area.	002c, d, e
3	2.25	2.85	00DKA102c	red shale and siltstone, with 3 - 4 green siltstone beds; green beds < 10 cm thick; contains gypsum nodules (to south in main pit); horizontal gypsum fracture at top.	002r
2	0.00	2.25	00DKA102b	dark brown-red shale, with brown-red and green (minor) siltstone hard beds.	002a, b
1	-1.05	0.00	00DKA102a	dark red shale, with (~25%) green shale and siltstone; most green beds < 5 cm thick; top marked by 25 cm thick green bed.	-

Table 3: Aldershot Quarry unit descriptions (all Queenston Formation).

unit #	bottom elevation	top elevation	composite sample #	unit description	bed samples (00DKA-)
8	16.85	22.20	none	mostly red shale, weathered towards top; top of west side of outcrop; not accessible for composite sampling.	014m, n
7	12.45	16.85	00DKA114g	red shale with green siltstone and shale interbeds (< 20%); capped by thin green bed; unit is at top of east side of section.	014j, 014k, 014l
6	10.15	12.45	00DKA114f	mostly red shale, with minor thin green siltstone and shale beds (especially in middle of unit); some small gypsum nodules near base of unit (basal 0.5 m).	014i
5	8.30	10.15	00DKA114e	red shale with thin to thick green (~25%) shale and siltstone interbeds; up to 0.45 cm thick green interval at base, overlain by up to 1.4 m mostly red interval, and capped by interbedded interval (60% red, 40% green); green siltstones commonly contain ripple cross-lamination; small gypsum nodules locally abundant (especially in middle red interval).	014g, 014h
4	5.30	8.30	00DKA114d	mostly red shale, with laterally discontinuous, < 10 cm thick, green beds (<10%); small gypsum nodules throughout (less abundant than units 1 and 2); gypsum-filled fractures @ 5.9 m and 6.6 m; top contact taken at base of green shale under light green siltstone.	014f
3	3.20	5.30	00DKA114c	interbedded red shale (80%) and green shale/siltstone; red intervals up to 1m thick; green beds range from < 5 to 10 cm thick, are commonly laminated and/or ripple cross-laminated, have coarser grained; green beds more abundant toward top of unit (above 4.8 m).	
2	0.40	3.20	00DKA114b	mostly red shale, with minor thin green shale and siltstone beds, locally abundant small gypsum nodules (especially in lower 2/3), and thin (< 3 mm) sub-horizontal gypsum-filled fractures between 1.2 m and 2.2 m; thin (< 20 cm) lens of light green, ripple cross-laminated, siltstone/line-grained sandstone, < 10 m wide at ~ 1.60 m.	014d, e
1	-1.25	0.40	00DKA114a	red shale (75%) with green shale and limestone interbeds; limestone beds commonly core green shale beds and are cross-laminated; small gypsum nodules locally abundant toward top of unit; unit capped by 5 cm green argillaceous limestone bed with horizontal and ripple cross-laminations; 0 m elevation is top of asphalt behind plant.	014a, b, c

Table 4: Milton Quarry unit descriptions (all Queenston Formation).

unit #	bottom elevation	top elevation	composite sample #	unit description	bed samples (00DKA-)
10	24.00	28.00	00DKA104i	weathered red shale, with sparse thin green beds; sampled only up to 25.50 m.	
9	20.70	24.00	00DKA104h	mostly dark red-brown shale, with few small to medium green mottles; capped with thin (~ 5 cm) green bed.	004n
8	16.40	20.70	00DKA104g	mostly dark red shale, with thin (< 10 cm) discontinuous green beds (< 10%); more green beds in upper 80 cm; capped by green bed; small calcite lined vugs @ 17.30 m.	004l, m
7	12.70	16.40	00DKA104f	dark red, massive shale (100%) in basal 2.5 m; overlain by 1.2 m of interbedded red (80%) shale and green (20%) beds; unit capped by green bed.	004j, k
6	9.00	12.70	00DKA104e	mostly dark red, massive shale, with thin, discontinuous green beds; capped by medium green bed.	004h, i
5	7.10	9.00	00DKA104d	mostly dark red, massive shale; capped by thin to medium green bed.	004f, g
4	5.50	7.10	00DKA104c	mostly dark red, massive, shale; with thin (< 5 cm) green shale beds; local green mottles; unit capped by "doublet" of green shale beds.	
3	4.95	5.50	00DKA104b	mostly green shale and siltstone; "triple" of green hard beds; 25 cm thick basal bed.	004e
2	0.00	4.95	00DKA104a	mostly dark red, massive shale; few green beds and large mottles; note: unit 1 (- 0.2 - 0 m) sampled as single bed (00DKA004a)	004d
1	-0.20	0.00	no sample	green, calcareous, shale; faint sub-horizontal lamination.	004b, c
					004a

Table 5: A.C. Martin (Georgetown) Quarry unit descriptions (all Queenston Formation).

unit #	bottom elevation (m)	top elevation (m)	composite sample #	unit description	bed samples (00DKA-)
3	5.25	11.00	00DKA106c	red shale with sparse discontinuous green beds and mottles; unit extends up to 11 m, but top 0.50 m is covered; topmost 0.75 m of sample is weathered - possibly contaminated with overburden.	006e, f
2	2.25	5.25	00DKA106b	red shale with thin, discontinuous green beds and medium to large green mottles.	006d
1	0.00	2.25	00DKA106a	red shale with 2 green shale/siltstone intervals (at 1.5 - 1.60 m and 2.15 - 2.25 m) with 2 to 3 thin beds each and associated large green mottles up to 50 cm thick; individual green beds grade laterally into red; large green mottles are locally enlarged along sub-vertical fractures; bottom 0.50 m covered (unit 1 starts at 0 m = quarry floor).	006a, b, c

Table 6: Cheltenham Quarry unit descriptions (all Queenston Formation).

# unit	elevation (m) bottom	elevation (m) top	composite sample #	unit description	bed samples (00DKA-)
6	16.85	22.35	00DKA103e	mostly red shale, with minor thin to thick green shale beds; scattered small green mottles; top 1.4 m is weathered.	003i, j
5	6.55	16.85	00DKA103d	mostly red shale, with minor thin to thick green shale beds; scattered small green mottles; unit capped by laterally persistent thin green hard bed.	003e, f, g, h
4	3.95	6.55	00DKA103c	red shale with some green mottles and laterally discontinuous green beds up to 25 cm thick, and small gypsum nodules; capped by two green beds up to 25 cm thick, with small scale cross-lamination.	003c, d
3	3.00	3.95	none	covered; interval between top of drainage ditch and south wall, covered with talus.	-
2	0.00	3.00	00DKA103b	red shale, red and green siltstone interbeds locally significant; sampled only up to 2.40 m in ramp wall/ sump; basal 1.35 m is red shale; whole unit, up to 3.00 m, exposed in drainage ditch; locally abundant small gypsum nodules (unit 3, @ 3.00 to 3.95 m, is covered and was not sampled).	003b
1	-0.60	0.00	00DKA103a	green and dark red siltstone; laterally discontinuous beds; unit capped by 10 cm green bed.	003a

APPENDIX 9

Locations of Ontario Geological Survey 2000 drill holes.

APPENDIX 9: Locations of Ontario Geological Survey 2000 drill holes (UTM coordinates are reported in NAD 83).

Drill Hole Number	Mapping Station Number	Location	UTM Easting (m)	UTM Northing (m)
OGS-00-A1	00DKA-045	on the northeast corner of the intersection of Highways 407 and 25 (Bronte Rd.); in the road allowance separating Lot 27, Concession 1N and Lot 27 of Concession 2N, Trafalgar Geographic Twp, Town of Oakville, Regional Municipality of Halton.	597916	4811095
OGS-00-A2	00DKA-046	adjacent to the northeast side of the Oakville Landfill site, at the southeast end of the Fourth Line Rd.; in the road allowance separating Lots 20 and 21, Concession 1N, Trafalgar Geographic Township, Town of Oakville, Regional Municipality of Halton.	600367	4814323
OGS-00-A4	00DKA-047	in the road allowance at the southeast end of the Third Line Rd., ~ 0.5 km southeast of Britannia Rd.; adjacent to Lot 3, Concession 3, Trafalgar Geographic Township, Town of Milton, Regional Municipality of Halton	596096	4815637
OGS-00-A6	00DKA-048	on the southeast side of the communications tower access road, on the northeast side of Mountainview Rd., 1.8 km southeast of the 10th Side Rd; in Lot 7, Concession 10, Esqueving Geographic Township, Regional Municipality of Halton.	592246	4829873
OGS-00-A8	00DKA-049	in the road allowance on the northwest side of the 10th Side Rd., beneath the transmission line, 0.7 km southwest of the 5th Line Rd.; adjacent to Lot 11, Concession 5, Esqueving Geographic Township, Regional Municipality of Halton.	587059	4826268
OGS-00-A10	00DKA-050	in the road allowance on the southeast side of the Wanless Rd., at the jog in the road, 0.7 km northeast of Heritage Rd.; adjacent to Lot 15, Concession 5W, Chinguacousy Geographic Township, City of Brampton, Regional Municipality of Peel.	591779	4837118
OGS-00-B1	00DKA-051	in the road allowance on the northwest side of the intersection of 15th Side Rd. and 1st Line East, adjacent to Lot 16, Concession 1 ECL, in Mulmur Township, Dufferin County.	569861	4892115
OGS-00-B4	00DKA-052	in the road allowance on the south side of 15/16 Side Road, approximately 1.3 km west of Fairgrounds Road, and 1.45 km east of Smithdale; adjacent to Lot 15, Concession 5, in Clearview Township, Simcoe County.	569122	4912183
OGS-00-C1	00DKA-053	in the Bayview Quarry, located approximately 1.8 km east of Grey Rd. #7, 0.65 km south of 7th Side Rd., 5 km south of Meaford and 1.6 km north of Griersville; in Lot 5, Concession 5, St. Vincent Township, Grey County. The quarry is operated by Harold Sutherland Const. and is located on land owned by Mr. S. Davison.	532847	4933652
OGS-00-C2	00DKA-054	in the road allowance on the west side of St. Vincent-Sydenham Rd., approximately 0.95 km south of Side Rd. 30; in the jog in the road adjacent to Lot 29, Concession 1, Sydenham Township, Grey County.	520908	4944428

APPENDIX 10

Quality control summary for Queenston Formation shale project analyses.

APPENDIX 10

Appendix 10: Quality control summary for Queenston Formation shale project analyses.
Estimated precision determined at 95% confidence level. Legend: XRF = X-ray fluorescence;
IRC = Infra-red spectroscopy; MDL = method detection limit.

Analyte	Analytical method	Units	MDL	Field samples (n = 490)			Estimated precision	
				Range		Average		
				minimum	maximum		+ or -	%
Al2O3	XRF	wt%	0.01	1.7	18.02	12.38	0.1375	1.11
CaO	XRF	wt%	0.01	0.44	48.05	12.01	0.1297	1.08
Fe2O3	XRF	wt%	0.01	0.68	8.17	5.09	0.02	0.39
K2O	XRF	wt%	0.01	0.47	5.47	3.63	0.0505	1.39
MgO	XRF	wt%	0.01	1.48	9.89	3.39	0.03	0.88
MnO	XRF	wt%	0.01	0.05	0.29	0.11	0.00	0.00
Na2O	XRF	wt%	0.01	0.02	1.37	0.47	0.03	6.38
P2O5	XRF	wt%	0.01	0.04	0.24	0.14	0.01	7.14
SiO2	XRF	wt%	0.01	5.32	63.3	47.03	0.3545	0.75
TiO2	XRF	wt%	0.01	0.05	0.96	0.63	0.01	1.59
LOI	XRF	wt%	0.05	5.74	40.46	14.5	0.04	0.28
Total	XRF	wt%	n/a	88.07	101.19	99.39	0.5	0.50
CO2	IRC	wt%	0.03	0.21	39.8	10.55	0.20	1.90
S	IRC	wt%	0.01	0.01	4.64	0.08	0.02	25.00

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	Multiplied by	Gives	Imperial Unit	Multiplied by	Gives
LENGTH					
1 mm	0.039 37	inches	1 inch	25.4	mm
1 cm	0.393 70	inches	1 inch	2.54	cm
1 m	3.280 84	feet	1 foot	0.304 8	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	1.609 344	km
AREA					
1 cm ²	0.155 0	square inches	1 square inch	6.451 6	cm ²
1 m ²	10.763 9	square feet	1 square foot	0.092 903 04	m ²
1 km ²	0.386 10	square miles	1 square mile	2.589 988	km ²
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
VOLUME					
1 cm ³	0.061 023	cubic inches	1 cubic inch	16.387 064	cm ³
1 m ³	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m ³
1 m ³	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m ³
CAPACITY					
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	4.546 090	L
MASS					
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	31.103 476 8	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	0.453 592 37	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	907.184 74	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	0.907 184 74	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	1016.046 908 8	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	1.016 046 90	t
CONCENTRATION					
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

MAPS NOT FILMED

**CARTES NON
REPRODUITES**

micromedia
a division of IHS Canada

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca